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# A NEW SPECIES OF *MELANOPSIS* FROM THE GOLAN HEIGHTS, SOUTHERN LEVANT (GASTROPODA: MELANOPSIDAE)

JOSEPH HELLER[1] & NAOMI SIVAN[1]

*Abstract A new species,* Melanopsis meiostoma, *is described from a single spring in the Golan Heights. It is characterised by a small shell aperture, relative to shell size.*

*Key words* Melanopsis, *systematics, Golan, Israel, Levant*

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## INTRODUCTION

The freshwater snail *Melanopsis* (Melanopsidae) has a broadly circum-mediterranean distribution (Banarescu, 1990–95) and its many isolated populations exhibit widely divergent shell phenotypes. Especially in the Levant, the systematics of *Melanopsis* has been the focus of much attention (Germain, 1921–2; Pallary, 1939; Tchernov, 1975; Schütt, 1983, 1988; Mienis, 1983; Mienis & Ortal, 1994; Burch, 1985; Glaubrecht, 1993, 1996; Heller, Sivan & Motro, 1999). This present paper concerns a population of exceptionally, slim, small-mouthed *Melanopsis,* which we hereby describe as a separate species.

## METHODS

Conchiometrics include shell height, maximal shell diameter, mouth height, mouth diameter, notch width and notch depth (see Heller, Sivan & Motro, 1999). In addition, to enable easier comparisons with any fossil material (where the shell aperture is frequently broken and maximal shell diameter difficult to measure), we also measured minimal shell diameter. All measurements are in millimeters, accurate to 0.1 mm. From these measurements, several ratios were calculated. Each shell was also scored for presence or absence of ribs; no ribs were found.

## SYSTEMATIC DESCRIPTION

### *Melanopsis meiostoma* sp. nov.
Fig. 1

*Diagnosis* *Melanopsis meiostoma* sp. nov. differs from *M. buccinoidea* Olivier 1801 in that it almost always has a smaller shell-diameter, relative to shell-height; a smaller mouth-height, relative to shell-height; a smaller mouth-diameter, relative to mouth-height; and a weaker callus.

*Description* The shell is small, narrow, and has up to eight whorls. It has a pointed spire, flattened whorls separated by very shallow sutures, and is smooth. The aperture is small (relative to shell height); and roundish, due to an outward flaring of the outer lip. Shell colour is uniform, dark-brown to black; also the columella and the (weakly developed) callus are blackish.

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*Measurements and ratios*

| **Shell character** | **Range** | **Mean ± SD** |
|---|---|---|
| Shell-height | up to 17.0 mm | |
| Maximal shell-diameter | up to 7.5 mm | |
| Minimal shell-diameter | up to 6.6 mm | |
| Mouth-height | up to 7.28 mm | |
| Mouth-diameter | up to 3.74 mm | |
| Notch-width | up to 3.7 mm | |
| Notch-depth | up to 3.6 mm | |
| Maximal shell-diameter/Shell-height | 0.39–0.49 | 0.45 ± 0.02 |
| Minimal shell-diameter/Shell-height | 0.37–0.45 | 0.39 ± 0.02 |
| Mouth-height/Shell-height | 0.42–0.53 | 0.47 ± 0.02 |
| Mouth-diameter/Mouth-height | 0.42–0.52 | 0.46 ± 0.02 |
| Mouth-height/Maximal shell-diameter | 0.95–1.20 | 1.05 ± 0.05 |
| Mouth-height/Minimal shell-diameter | 1.05–1.35 | 1.19 ± 0.06 |
| Notch-width/notch-depth | 0.84–1.09 | 0.95 ± 0.06 |
| Notch-width/mouth-diameter | 0.34–0.66 | 0.54 ± 0.06 |
| Notch-depth/Mouth-diameter | 0.39–0.72 | 0.56 ± 0.05 |

In most specimens in our sample the periostracum is eroded. (n = 40)

*Material* Holotype no. HUJ 7966 and 39 paratypes (HUJ 7967), in the national mollusc collection of the Hebrew University, Jerusalem.

*Type locality* En Haruv (IG 2119-2405), a small spring on the Golan Heights that pours into a small cement pool. Water analysis reveals that this spring is brackish with a high value of $Cl^-$, both absolutely and relative to $Na^+$ (Table 1).

*Etymology* **Meio** in Greek is less, **stoma** is mouth. The name *'meiostoma'* refers to the small aperture of the shell.

*Discussion* *M. meiostoma* is similar to *M. buccinoidea* in that it has a smooth shell. It differs from *M. buccinoidea* in that it has a more narrow shell, a smaller, more round aperture and a larger notch (relative to aperture size). A comparision of *M. meiostoma* with 200 *M. buccinoidea* from ten (pooled) sites in the nearby Jordan Valley reveals that *M. meiostoma* has significantly lower ratios of shell-diameter/shell-height, mouth-height/shell-height and mouth-height/shell-diameter; and higher ratios of mouth-diameter/mouth-height, notch-width/mouth-diameter and notch-depth/mouth diameter (t-test, $p < 0.01$). Fig. 2 shows conchiometrics which diagnostically separate *M. meiostoma* from *M. buccinoidea* .

*M. meiostoma* differs from *M. costata* Olivier 1804 (found in Lake Kinneret, 2–3 km west of En Haruv) and from *M. saulcyi* Bourgignat 1853 (found 8 km further south) in that it is smooth, not costated. *M. meiostoma* differs from *M . costata* of Lake Kinneret also in the ratios shell-diameter/shell-height, mouth-diameter/mouth-height and mouth-height/shell-height. *M. meiostoma* is similar to *M. saulcyi* in the ratio shell-diameter/shell-height, but differs in all the other shell parameters.

*M. meiostoma* differs from *M. eremita* Tristram (1865), described from En Boqeq (a little stream south-west of the

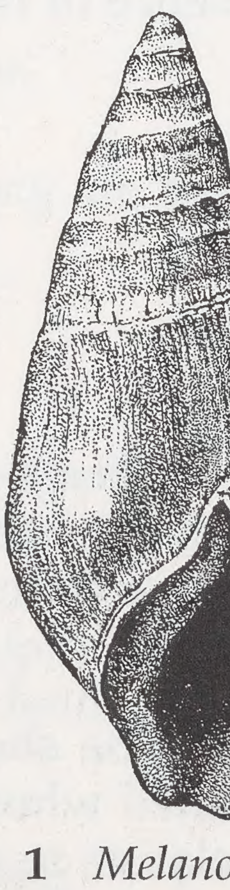

**Fig. 1** *Melanopsis meiostoma*, sp. nov. Type specimen, from En Haruv.

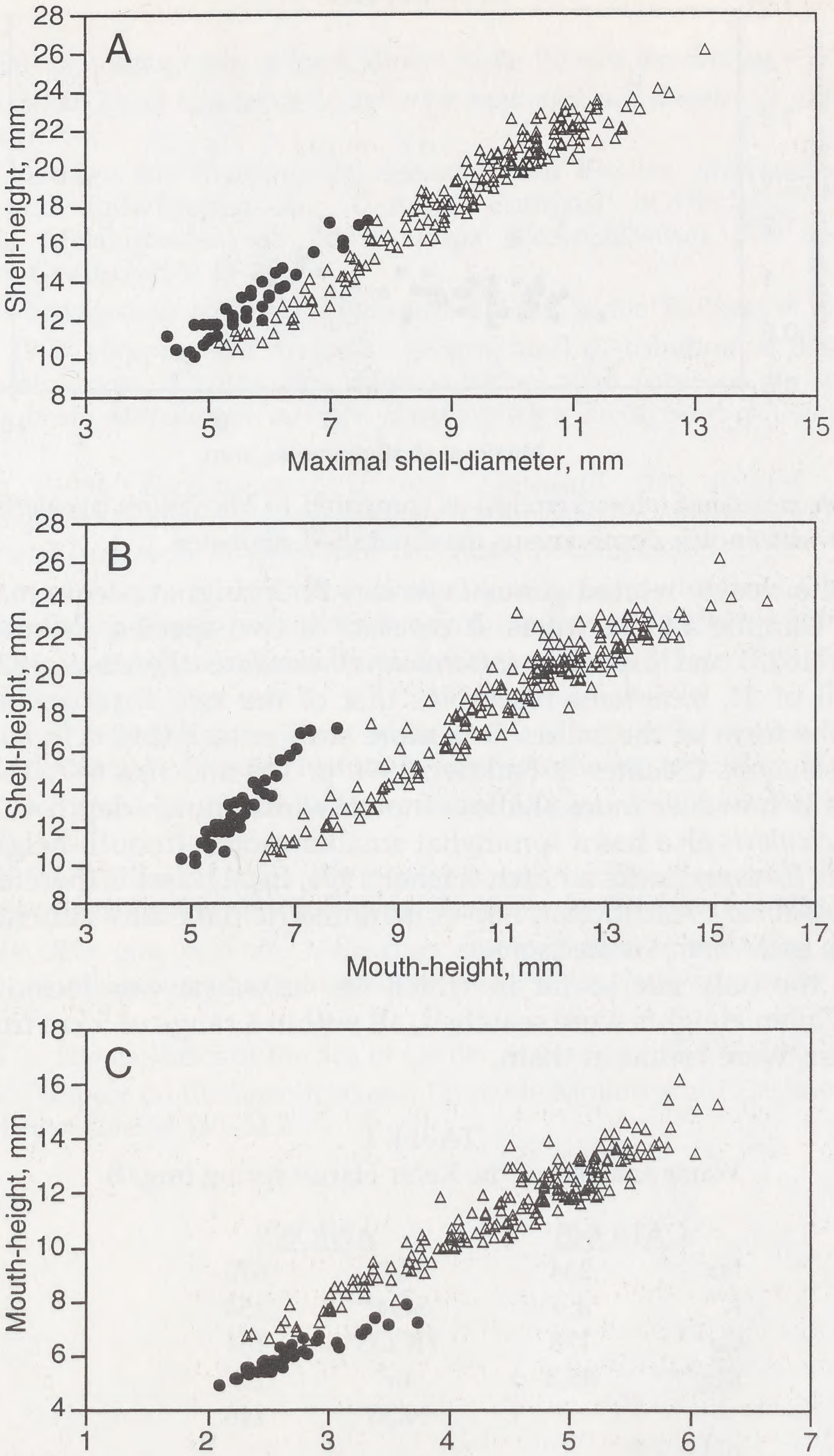

**Fig. 2** *Melanopsis meiostoma* (closed circles) as compared to *M. buccinoidea* (open triangles): **A** Shell-height versus maximal shell-diameter. **B** Shell-height versus mouth-height. **C** Mouth-height versus mouth-diameter.

Dead Sea, 180 km south of En Haruv) in that its ratios mouth-height/shell-height and mouth-height/shell diameter are lower and the ratio mouth-diameter/mouth-height is higher. Further, in *M. eremita* the shell is semi-transparent and the callus and collumella are white, whereas in *M. meiostoma* the shell is dark-brown to black and collumella and callus are dark.

Whereas the genus *M. Melanopsis* ranges from Spain via Turkey and the Levant into

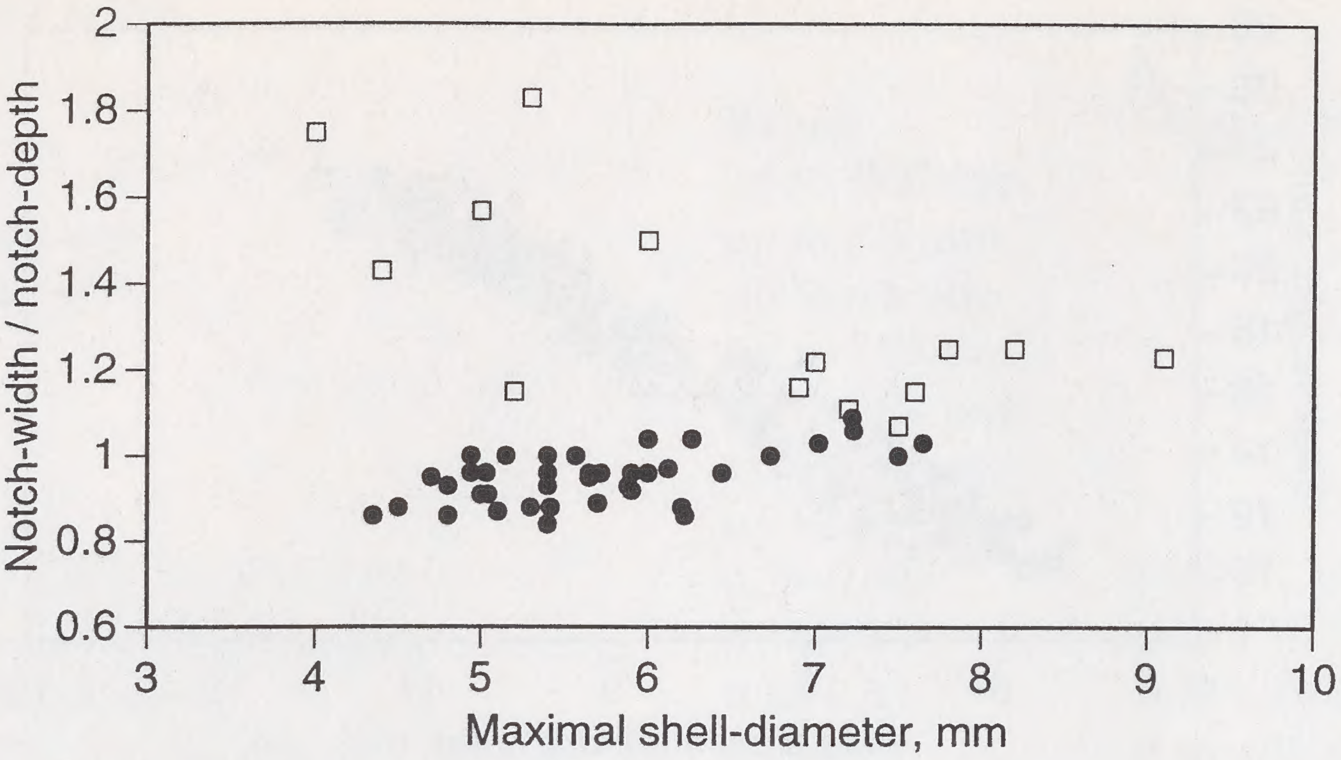

**Fig. 3** *Melanopsis meiostoma* (closed circles) as compared to *Microcolpia acicularis* (open squares): The ratio notch-width/notch-depth versus maximal shell-diameter.

Iraq and Iran, the closely related genus *Esperiana* Bourguignat occurs mainly in eastern Europe, in the Danube and its inlets. It consists of two species, *Esperiana* (*Esperiana* ) *esperi* (Férrusac 1823) and *Esperiana (Microcolpia) acicularis* (Férrusac 1823) (see Fischer 1994). The shell of *M. meiostoma* resembles that of the two *Esperiana* species in shell shape, and in the form of the callus. It is more similar to *E.(M.) acicularis* which has a notch, as in *Melanopsis* (Fechter & Falkner, 1990 p. 128 and figs 6–7, 11). The notch of *E.(M.) acicularis* is however more shallow (notch-width/notch-depth = 1.36 ± 0.26; see Fig. 3). *E.(M.) acicularis* also has a somewhat smaller mouth (mouth-height/shell-height = 0.43 ± 0.03). *E.(E.) esperi* lacks a notch (Fisher 1994, fig. 1), and is therefore more different from *M. meiostoma* . Additional, non-conchiometric data may ellucidate the precise generic position of *Melanopsis meiostoma.*

En Haruv is the only site so far in which *M. meiostoma* was found. Several other springs on the Golan Heights were searched, all within a range of 5 km from Kfar Haruv, but no *Melanopsis* were found in them.

TABLE 1
Water analysis of the Kefar Haruv spring (mg/l).

| CATIONS | | ANIONS | |
|---|---|---|---|
| $Na^+$ | 234 | $Cl^-$ | 670 |
| $K^+$ | 4.4 | $SO4^=$ | 154 |
| $Ca^{++}$ | 178 | $HCO3^-$ | 151 |
| $Mg^{++}$ | 83.3 | $Br^-$ | 2.5 |
| | | $NO3^-$ | 146 |

pH = 7.2

## ACKNOWLEDGEMENTS

The British Museum (Natural History) lent us the syntypes of *M. eremita.* Mrs Sarah Ehrlich kindly carried out the water analysis. Prof. K. Bandel kindly gave us the *Esperiana* shells, for comparison. While collecting *Melanopsis* for this study, an unidentified son-of-a-bitch stole my car; it was later found with a wrecked chassis, which cost me $ 4000 to repair. As this little paper has 1557 words, this means $ 2.569 per word. Is this the most expensive malacological paper ever to have been written?

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# FOUR SPECIES OF THE FAMILY FASCIOLARIIDAE (GASTROPODA) FROM THE NORTH ATLANTIC SEAMOUNTS

SERGE GOFAS[1]

*Abstract* *Four species of Fasciolariidae from the North Atlantic Seamounts around Great Meteor Bank are reported on, and a new species,* Fusinus meteoris *is described. One of the species is identified to* Clathurella rugosissima *Locard, 1897, which is here assigned to the genus* Latirus. *The larval development, as inferred from the morphology of the protoconch, is planktotrophic in* Latirus rugosissimus, Fusinus amiantus *and* F. bocagei, *but* F. meteoris, *which has a teleoconch morphology very similar to* F. bocagei, *has a paucispiral larval shell indicating direct development.* Latirus rugosissimus *appears to have a restricted range on the seamounts, where it is abundant, and this cannot be explained by a lack of ability for dispersal. Conversely, the direct developer* Fusinus meteoris *is found on Meteor, Hyères and Irving seamounts, separated by a distance of* ca. *90 km and does not show any morphological differenciation.*

*Key words* *Fasciolariidae, North Atlantic, larval dispersal*

## INTRODUCTION

The Fasciolariidae is a gastropod family where different types of larval development can be found in species which are hardly different in their adult morphology. This paper treats the species of this family collected on the North Atlantic Seamounts by the Seamount 2 expedition. The Fasciolariidae are conspicuous elements of the molluscan macrofauna there, with 4 common species of which one was undescribed.

The Seamount expeditions were aimed at general collecting of the benthic fauna and at a better understanding of the colonization of isolated sites by the benthic species. Seamount 1 was conducted in September/October 1987 by Philippe Bouchet (of Muséum National d'Histoire Naturelle, Paris, hereafter MNHN) and visited Gorringe, Josephine, Ampère, Lion and Seine seamounts (57 dredge hauls and 10 beam trawl operations shallower than 1000 m). Seamount 2 was conducted in January/February 1993 by the author and visited the Great Meteor Bank, Hyères, Irving, Plato, Atlantis and Tyro seamounts (69 dredge hauls and 16 beam trawl operations shallower than 1000 m).

A major characteristic of the physical environment on the Seamounts is the lack of any terrigeneous input of fine sediments, contrary to what happens on continental margins. The only source of new sediment, apart from the erosion of the geological structure itself, is the production of bioclasts by pelagic and benthic organisms (von Rad, 1974). This is a slow process, and allows time for winnowing away most of the fine particles. As a consequence, the seamounts are an unusual environment, where large areas of rock and gravel are available in the 200–1000 m depth interval, usually clad with sediments on the continental margin.

With the cumulative effects of the differences in substrate, and the distances from the mainland in the order of magnitude of 1000 km, the seamounts are prone to have endemic elements in their fauna.

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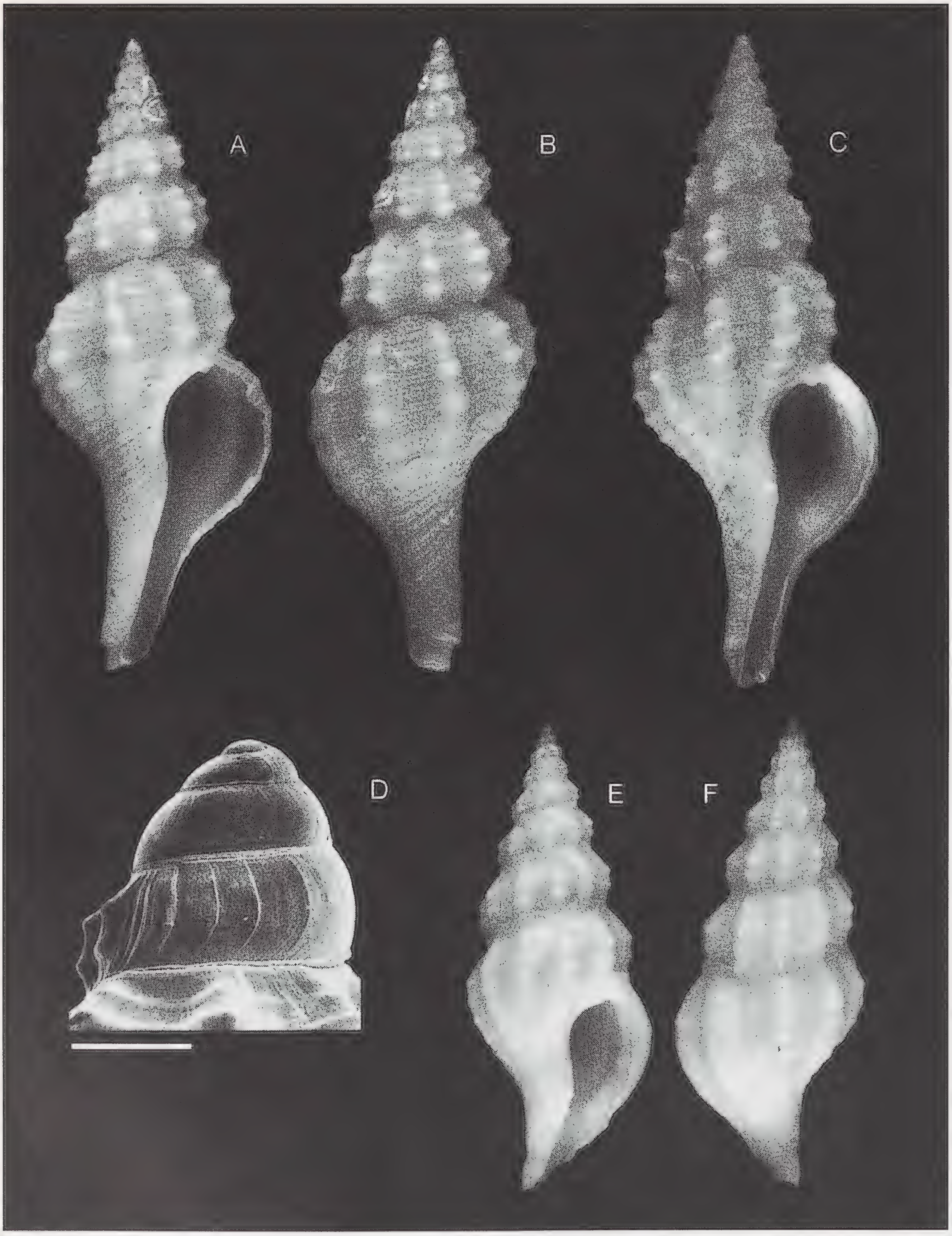

**Fig. 1** *Fusinus* species with planktotrophic larvae. **A–B** *F. bocagei* from Hyères bank, DW 188 (31.3 mm); **C** *F. bocagei* from Hyères bank, DW 192 (31.6 mm), a gerontic specimen with thickened, bevelled inner side of lip; **D** Protoconch of *F. bocagei* from Hyères bank, DW 188 (Scale bar = 0.5 mm) **E–F** *F. amiantus* from Hyères bank, DW 185 (20.2 mm).

## MATERIALS AND METHODS

Most of the collected material consisted of shells, and these were taken into account in the mollusc counts. The coarse fractions, usually above 10 mm, were mostly sorted on board at the phylum level, then sorted to species level in the lab. The finer fractions were preserved on board, and later sieved through 5 mm, 2 mm, 1 mm, 0.5 mm and 0.3 mm sieves, and sorted under a stereomicroscope. Except for extremely juvenile specimens which were not retained on the 5 mm sieve, most of the Fasciolariidae were found in the coarse fractions sorted on board.

The material was sorted to the species level. The provisional listing of molluscs for the depth interval shallower than 500 m records several thousand specimens representing 242 species in the Lusitanian seamounts, and 182 species in the Meteor group seamounts. Most of the specimens and species are in the size range 1–5 mm. The material from Seamount 1 is shared between MNHN and Naturhistoriska Riksmuseet, Stockholm, that from Seamount 2 is deposited in the malacological collection of MNHN.

Abbreviations used:
**sh** shell(s), collected empty
**spm** specimen(s), collected alive
**CP** Beam trawl
**DE** Epibenthic sled
**DW** Warén rock dredge
**MNHN** Muséum National d'Histoire Naturelle, Paris
**USNM** Smithsonian Institution, Washington.

## SYSTEMATICS

### FASCIOLARIIDAE

### Genus ***Fusinus*** Rafinesque, 1815
Type species *Murex colus* Linné, 1758
(subsequent designation by Schumacher, 1817)

### ***Fusinus bocagei*** (P. Fischer, 1882)
Fig. 1 A–C

*Fusus bocagei* P. Fischer, 1882: 49 — Locard, 1897: 329–330.

*Lectotype* (Bouchet & Warén, 1985) in MNHN, from Travailleur, 1881, dredge 1 or 2 (mixed labels).

*Other material examined* **Gorringe** DW 08 (36°28′N - 11°37′W, 470–485 m): 4 sh.; CP 11 (36°26′N - 11°40′W, 805–830 m): 1 sh.; CP 12 (36°24′N - 11°43′W, 1005–1040 m): 1 sh.; DW 21 (36°35′N - 11°28′W, 460–480 m): 9 sh.; **Josephine** DW 61 (36°40′N - 14°16′W, 200–205 m): 1 sh.; Lion: DW63 (35°15′N - 15°35′W, 630 m): 4 sh.; Seine DE 84 (33°48′N - 14°24′W, 450–455 m): 1 sh.; **Ampère** CP99 (35°04′N - 12°55′W, 225–280 m): 1 sh. Meteor: DW 148 (30°12.0′N - 28°24.6′W, 615 m): 1 sh.; DW 152 (30°02.0′N - 28°22.1′W, 470 m): 1 sh.; DW 167 (30°04.6′N - 28°42.1′W, 520 m): 2 (wet) spm.; DW 179 (30°00.6′N - 28°42.3′W, 730 m): 1 sh.; **Hyères** DW 182 (31°23.2′N - 28°53.5′W, 480 m): 2 jv sh.; DW 184 (31°24.4′N - 28°52.3′W, 705 m): 2 sh.; DW 188 (31°30.0′N - 28°59.5′W, 310 m): 3 sh.; DW 190 (31°29.0′N - 29°00.0′W, 750 m): 7 sh.; DW 202 (31°16.5′N - 28°43.1′W, 640 m): 6 sh.; DW 203 (31°09.5′N - 28°43.5′W, 845 m): 1 sh.; **Irving** DW 208 (32°03.9′N - 27°53.9′W, 790 m): 2 sh.; DW 209 (31°59.2′N - 27°55.9′W, 460 m): 8 sh.; DW 218 (31°52.3′N - 28°03.6′W, 480 m): 4 sh.; DW 219 (32°01.0′N - 27°53.3′W, 760 m): 3 sh.; DW 225 (32°08.6′N - 28°10.7′W, 1035 m): 1 sh.; DW 226 (32°06.7′N - 28°08.8′W, 580 m): 1 frg sh.; DE 227 (32°07.2′N - 28°08.7′W, 695 m): 1 sh.; DW 231 (32°01.5′N - 27°54.5′W, 745 m): 2 spm. + 10 sh.; DW 237 (32°15.9′N - 27°31.8′W, 670 m): 1 + 3 jv sh.; DW 238 (32°17.3′N - 27°32.3′W, 890 m): 1 sh.; **Plato** DW 240 (33°12.3′N - 29°01.9′W, 565 m): 16 spm. + 5 sh.; DW 241 (33°11.9′N - 28°59.3′W, 695 m): 10 spm. + 20 sh.; DW 242 (33°11.8′N - 28°57.0′W, 710 m): 1 spm. + 2 sh.; DW 246 (33°13.9′N - 29°36.1′W, 520 m): 2 sh.; DW 248 (33°13.6′N - 29°32.5′W, 735 m): 2 spm. + 10 sh.; Atlantis DW 258 (33°59.8′N - 30°12.1′W, 420 m): 12 sh.

*Type locality* Off Portugal, (43°01′N - 09°37′W, 2018 m or 41°43′N - 09°19′W, 1068 m).

*Remarks* This species has been reviewed and its synonymy established by Bouchet & Warén (1985), and not much is to be added except for the new material. The species is common on the banks, and its bathymetric distribution (470–615 m on Meteor, 310–890 m on Hyères, 460–1035 m on Irving, 520–735 m on Plato) is consistent with that given for around the Azores by Bouchet & Warén (1985). It is not normally found on the upper plateau, but rather on the uppermost part of the slope of the seamounts.

### ***Fusinus amiantus*** (Dall, 1889)

Fig. 1 E–F

*Fusus amianta* Dall, 1889: 169, pl. 15 fig. 11.

*Type material* (not seen) Holotype USNM 508726.

*Material examined* **Meteor** DW 148 (30°12.0′N - 28°24.6′W, 615 m): 1 sh.; DW 173 (30°03.5′N - 28°43.6′W, 920 m): 6 spm.; DW 180 (30°04.1′N - 28°45.1′W, 1575 m): 2 (wet) spm.; **Irving** DW 218 (31°52.3′N - 28°03.6′W, 480 m): 1 sh.; DW 221 (32°17.8′N - 28°15.3′W, 1180 m): 4 sh.; CP 224 (32°12.2′N - 28°15.4′W, 1240 m): 3 sh.; DW 225 (32°08.6′N - 28°10.7′W, 1035 m): 10 spm.; **Plato** DW 248 (33°13.6′N - 29°32.5′W, 735 m): 1 spm.

*Type locality* Off Havana, Cuba, 1480 m.

*Remarks* This species, like the previous one, was reviewed by Bouchet & Warén (1985), who reported it as common around the Azores but not on the continental slope of Europe and gave good figures of shells and protoconch. The bathymetric range of *F. amiantus* is deeper than that of *F. bocagei* (Meteor: 615–1575 m, Irving: 1 shell at 480 m, then 1035–1240 m, Plato: 735 m) but both species can be found in the same sample.

### ***Fusinus meteoris*** n. sp.

Fig. 2 A–F

*Holotype* 1 shell from Seamount 2 sta. DW 172 (49.8 x 17.4 mm).

*Paratypes* 3 shells from Seamount 2 DW 172 (46.2 x 16 mm, 13.9 x 5.3 mm, 12.2 x 4.5 mm) and from DW 152 (39.6 x 5.4, and 2 juveniles). MNHN collection, no catalogue numbers.

*Other material examined* **Meteor** DW 136 (30°01.5′N - 28°28.3′W, 305 m): 1 jv. sh.; CP 146 (30°11.2′N - 28°28.1′W, 420 m): 2 sh.; DW 152 (30°02.0′N - 28°22.1′W, 470 m): juv. sh.; DW 159 (29°44.3′N - 28°20.4′W, 330 m): 1 sh.; **Hyères** DW 182 (31°23.2′N - 28°53.5′W, 480 m): 1 sh.; DW 188 (31°30.0′N - 28°59.5′W, 310 m): 25 sh.; **Irving** DW 205 (32°01.1′N - 27°57.2′W, 348 m): 1 sh.; CP 207 (31°59.7′N - 28°00.4′W, 260 m): 1 sh.; DW 209 (31°59.2′N - 27°55.9′W, 460 m): 5 sh.; DW 210 (32°02.6′N - 27°56.0′W, 320 m): 12 sh.; DW 215 (31°53.6′N - 28°02.9′W, 275 m): 4 sh.; DW 217 (31°53.5′N - 28°03.1′W, 270 m): 1 jv sh.

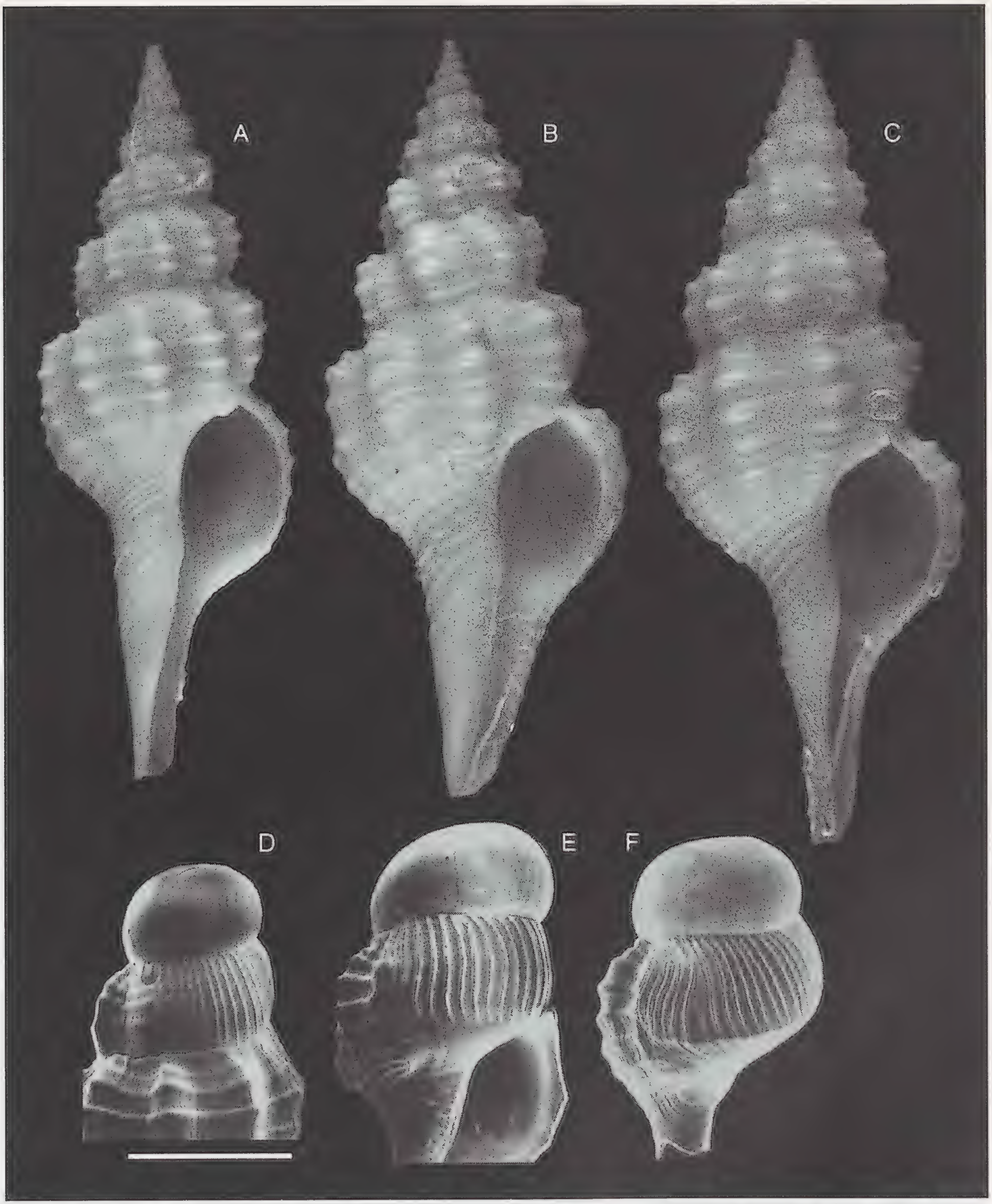

**Fig. 2** *Fusinus meteoris* n. sp. **A** Holotype from Great Meteor bank, DW 172 (49.8 mm); **B** specimen from Hyères bank, DW 188 (53.5 mm); **C** specimen from Irving bank, DW 215 (53.3 mm); **D** protoconch of a specimen from Hyères bank, DW188; **E–F** protoconchs of specimens from Meteor bank, DW 152 (Scale bar = 1 mm).

*Type locality* Great Meteor bank (30°05.1′N - 28°41.5′W, 455 m).

*Description* Shell 40 to 72 mm, elongate fusiform, of 8–9 whorls, whitish. Protoconch 1 ¼ whorls, with globose nucleus and subsequent whorl constricted; protoconch whorls slightly convex, with maximum convexity near the suture; the later part with delicate axial folds. Protoconch/teleoconch limit well marked, orthocline. Teleoconch of 7–8 whorls, moderately solid. Spire whorls convex, slightly shouldered, with 10 strong, widely spaced axial folds overrun by spiral cords. Three major spiral cords throughout teleoconch whorls, forming elongate knobs at intersection with straight, slightly proso-

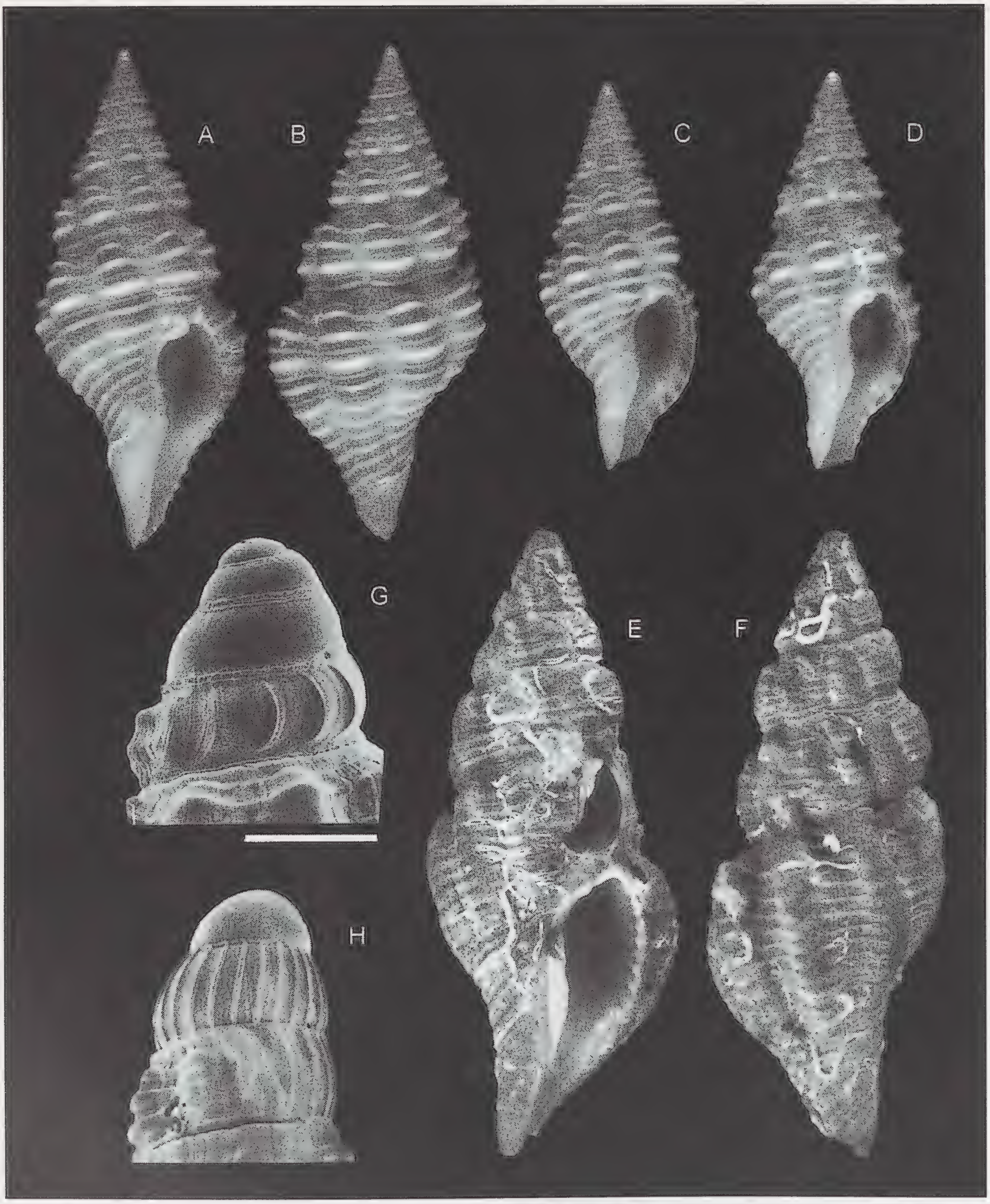

**Fig. 3** *Latirus* species with planktotrophic larvae. **A–B, C** *L. rugosissimus* (Locard, 1897), specimens from Hyères bank, DW 188 (20.1 and 15.6 mm); **D** specimen from Great Meteor bank, DW 172 (13.4 mm); **E–F** holotype of *Clathurella rugosissima*, off Madeira, Travailleur 1882 dredge 54 (27.2 mm); **G** protoconch of *L. rugosissimus* from Hyères bank, DW 188; **H** protoconch of *Latirus filosus* (Schubert & Wagner, 1829) from off Luanda, Angola, 40–60 m (Scale bar = 0.5 mm).

cline axial folds; smaller subsutural and suprasutural cords added from penultimate whorl onwards. Second-order spiral threads between major cords hardly apparent on the first four teleoconch whorls, grading to three in each interspace on penultimate and body whorl. Body whorl with rounded periphery and a long, straight, tapering siphonal canal, with *ca*. 20 spiral cords, somewhat unequal in size but not alternating, less prominent towards the tip of the canal.

Aperture oval, merging abapically into the quite open siphonal canal. Parietal edge bearing anteriorly a very weak knob, very close to the attachment of the outer lip.

Columellar edge smooth, appressed. Outer lip with a thin edge, smooth inside, weakly notched at the termination of the spiral cords. Inside of the aperture with very faint spiral grooves in the deeper visible part.

Colour of protoconch whitish; teleoconch also whitish, grading to a very faint tan colour between the axial folds; interior of aperture white.

*Remarks* *Fusinus gigliolii* (Monterosato, 1890) is the only described non-planktotrophic deep-water species in European waters. In using the words (in translation) "the type of this species was dredged in deep waters of the Mediterranean by the Italian expedition of the Washington", Locard (1897: 332) designated a lectotype from the Tyrrhenian Sea, of which the whereabouts are not known. I agree with Bouchet & Warén (1985: 160) that this may be a deep-water form of the widespread and variable Mediterranean *Fusinus rostratus* (Olivi, 1792).

Bouchet & Warén (1985) also figure a specimen of an undescribed non-planktotrophic *Fusinus* dredged by "Travailleur" 1882 station 39, off Morocco (34°11′N - 07°39′W, 530 m), which differs from the Seamount species in being considerably smaller (16.5 mm), in lacking a parietal knob, and in having well rounded whorls with flexuose ribs.

There is a report of a species with direct development on the slope of Bermuda, *Fusinus lightbourni* Snyder, 1984. This species is in the same size range as *F. meteoris,* but differs considerably in morphology of the teleoconch: The folds are more numerous and closer set, more wavy and flexuose, and the spirals do not make knobs at intersections.

The closest relationship as can be inferred from morphology is with *F. bocagei,* mainly distinguished by being smaller (large specimens on the seamounts reach 30 mm) and having a multispiral protoconch. The pattern of sculpture with widely spaced, straight and slightly prosocline axial folds, knobs at intersections of spirals is however basically the same.

*Fusinus meteoris* is a member of the genuine "seamount fauna", i.e. that restricted to the upper part of the seamounts (330–470 m on Meteor, 310–480 m on Hyères, 260–460 m on Irving). There is hardly any morphological difference between specimens from the different seamounts.

### Genus ***Latirus*** Montfort, 1810
Type species *Latirus aurantiacus* Montfort, 1810
(= *Murex gibbulus* Gmelin, 1791) by monotypy

### ***Latirus rugosissimus*** (Locard, 1897)
Fig. 3 A–G

*Clathurella rugosissima* Locard, 1897: p. 237–238, pl. 11 figs 18–20.

*Holotype* Old shell (27.2 mm) from "Travailleur" 1882 station 54. MNHN collection, no catalogue numbers.

*Other material examined* **Meteor** DW 145 (30°11,4′N - 28°28.5′W, 470 m): 3 sh.; DW 147 (30°11.2′N - 28°27.1′W, 340m): 4 sh.; DW 148 (30°12.0′N - 28°24.6′W, 615 m): 3 sh.; DW 152 30°02.0′N - 28°22.1′W, 470m): 35 sh.; DW 159 (29°44.3′N - 28°20.4′W, 330 m): 5 sh.; DW 166 (29°36.0′N - 28°22.8′W, 575 m): 1 sh.; DW 167 (30°04.6′N - 28°42.1′W, 520 m): 1 sh.; DW 172 (30°05.1′N - 28°41.5′W, 455 m): 9 sh.; DW 179 (30°00.6′N - 28°42.3′W, 730 m): 3 sh.; **Hyères** DW 182 (31°23.2′N - 28°53.5′W, 480 m): 6 sh.; DW 188 (31°30.0′N - 28°59.5′W, 310 m): 16 spm. + 150 sh.; DW 190 (31°29.0′N - 29°0.00′W, 750 m): 12 sh.; Irving: DW 209 (31°59.2′N - 27°55.9′W, 460 m): 30 sh.; DW 210 (32°02.6′N - 27°56.0′W, 320 m): 4 sh.; DW 215 (31°53.6′N - 28°02.9′W, 275 m): 3 sh.; DW 218 (31°52.3′N -

28°03.6′W, 480 m): 3 sh.; **Plato** DW 240 (33°12.3′N - 29°01.9′W, 565 m): 1 sh.; DW 246 (33°13.9′N - 29°36.1′W, 520 m): 3 spm. + 2 sh.; DW 247 (33°13.7′N - 29°35.3′W, 580 m): 1 spm.; **Atlantis** DW 255 (34°04.9′N - 30°15.3′W, 340 m): 2 spm.; DW 256 (34°06.2′N - 30°16.0′W, 340 m): 1 spm.; CP 257 34°04.5′N - 30°15.0′W, 338 m): 1 spm.

*Type locality* Madeira (32°40.3′N - 16°38′W, 400 m).

*Redescription* (based on Seamount material) Shell usually 15 to 20 mm, elongate fusiform, of 9–10 whorls, brightly coloured. Protoconch 3 ¼ whorls, high conical with blunt apex; protoconch whorls slightly convex, the first three smooth with a distinct suprasutural thread, the last ¼ with strong, widely spaced arched folds parallel to the protoconch/teleoconch limit, and some very minute granules (visible only under SEM) in the intervals. Teleoconch of 6–7 quite heavy whorls. Spire whorls convex, maximum convexity near the suture of the following whorl, with 7 broad rounded axial ribs overrun by three spiral cords, the abapical one stronger. Body whorl with rounded periphery and a moderately long, straight, tapering siphonal canal, with 8–10 main spiral cords, more delicate spiral threads on the canal and occasionally a spiral thread intervalated between two main cords. Aperture comma-shaped, with the parietal edge bearing anteriorly a strong fold and then forming a deep embayment where joining the columella; the columella with a convex part bearing four weak folds, then straight in its anterior portion. Outer lip with a thin edge, weakly denticulated at the termination of the spiral cords, thickened at some distance inside, with 6–7 raised spiral folds on the thickened part and continuing inside the shell.

Colour of protoconch plain brown, of teleoconch a pale greyish brown with yellow lines along the cords, dark brown intervals between cords on the ribs, all grading to a white siphonal canal; interior of aperture white.

*Remarks* The type specimen of *Clathurella rugosissima* (fig. 3E–F) is a very worn specimen, and is substantially larger than the specimens collected on the seamounts (27.2 mm instead of 15–20 mm). However, a close examination of the spire whorls reveals a pattern of sculpture which is identical on the whorls other than the last one, and there is still a trace of the peculiar colour pattern with darker interspaces and light cords. The holotype has a distinct growth stage marked at the size which would be that of the seamount specimens, and this suggests that it is a gerontic specimen which had resumed growth. The type locality is stated in Locard's text as North of the Canaries but is actually on the Eastern slope of Madeira, as can be noted from the coordinates in the manuscript station list (MNHN).

The alternative to using this name for the Seamount population would be to leave it unused and name a new species of *Latirus*, potentially a synonym. Additional material from the Madeiran type locality would be needed to assess the type of larval development there and prove or disprove that the two populations are conspecific.

The bathymetric range of *Latirus rugosissimus* on the banks is fairly shallow (330–615 m on Meteor, 310 m on Hyères, 275–480 m on Irving, 520–580 m on Plato, 338–340 m on Atlantis), overlapping with those of *Fusinus meteoris* and *F. bocagei.*

The West African *Latirus filosus* (Schubert & Wagner, 1829) is similar in appearance, but much larger (over 70 mm) and has the dark lines on the cords rather than interspaces. The protoconch is also multispiral but has a totally different architecture with a blunt tip, parallel sided second whorl, axial folds rather than sharp ribs, and no suprasutural thread (fig. 3H). Some forms referred to the West Indian *L. angulatus* (Röding, 1798) are also similar but also have the dark lines on the spirals and have a much shorter canal.

## DISCUSSION

The existence of a species of *Latirus* which has a planktotrophic larva, which is common on the Seamounts and has not been reported elsewhere, should call for some comments. This is a group that has received much attention in the recent literature (Bullock, 1974; Lyons, 1991; Sunderland & Sunderland, 1996) and it is at least rare, if not absent, in the Caribbean. There are similar cases for species with planktonic larvae wihich are restricted to insular sites, both in littoral species *(Littorina striata* King & Broderip, 1832; see de Wolf *et al.*, 1998) and species from deeper water *(Cytharomorula grayi* (Dall, 1889) see Bouchet & Warén, 1985: 150). The two other species with planktonic larval development have ranges which include a part of a mainland slope, but *F. bocagei* is prevalently European whereas *F. amiantus* was described from an American type locality and is not known on the continental shelf of Europe or NW Africa.

The other point to be raised about dispersal is that there is no seamount-to-seamount endemism of *Fusinus meteoris*, which is found on three seamounts separated by distances of 90–100 km horizontally, and by depths exceeding (between Meteor and Hyères) or approaching 4000 m. This means that those relatively short distances can be easily bridged, most likely through the rafting of egg capsules. Egg capsules referable to Fasciolariidae were not collected on the seamounts, and very little is known of the spawn of *Fusinus* species. Knudsen (1950) described egg capsules of an unidentified direct-developing species from West Africa. Miloslavich & Penchaszadeh (1997) reported on the spawn of *Fusinus closter* (Philippi, 1850), a large species also with direct development, and found large masses of capsules nearly 1 cm long, which hatch after 45–50 days.

The morphological observations on the protoconchs may lead to further questions regarding the generic placement of the species. There is a remarkable similarity between the protoconchs of *Latirus rugosissimus* and those of *Fusinus bocagei* and *F. amiantus;* conversely, the planktotrophic protoconch of the West African *L. filosus* is extremely different. If equal significance is given to the protoconch morphology and to the existence of columellar folds in the adult, then these characters are conflicting for the grouping of the above three species. An alternative possibility is that the columellar folds can be lost or acquired in unrelated lineages. This should be investigated on a large array of species and is not within the scope of this paper, but must be taken into account if the phylogeny of the family is studied.

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# ADDITIONS TO THE BIVALVE FAUNA OF THE RED SEA WITH DESCRIPTIONS OF NEW SPECIES OF LIMOPSIDAE, TELLINIDAE AND SEMELIDAE

P.G. OLIVER[1] & M. ZUSCHIN[2]

*Abstract An intensive survey of molluscan associations with coral reef and sedimentary facies in Safaga Bay, Northern Red Sea, revealed a number of taxa either new to the Red Sea or new to science. Species new to science belong to the genera:* Limopsis *(Limopsidae);* Semelangulus *(Tellinidae) and* Abra *(Semelidae). Species recorded for the first time from the Red Sea are:* Ctenoides concentrica *(Limidae);* Codakia paytenorum *(Lucinidae);* Leptomyaria etesiaca *(Semelidae) and* Costellipitar chordatum *(Veneridae). The genus* Offadesma *(Periplomatidae) is recorded but from a single valve only, which is of uncertain species status.* Ventricolaria toreuma *(Veneridae) is confirmed to be of frequent occurrence following its first recorded presence in 1995.*

*Key words Bivalvia, Red Sea, new species, first records.*

## INTRODUCTION

During the years 1995 to 1997 an extensive study of the molluscan assemblages associated with or adjacent to coral communities was made in the Northern Bay of Safaga, Red Sea (Zuschin & Piller 1997a, b, c; Zuschin & Hohenegger 1998). Over 700 taxa were recognised, of which 250 were bivalves. Preliminary identifications were made using Oliver (1992) but there were a number of taxa which could not be determined. A few examples are of moderately large species but the majority are small or minute and are present as dead shells or valves only. Most are, however, sufficiently distinct to warrant their description and this is necessitated by their high frequency in some facies.

## METHODS

*Sampling sites* All of the material presented in this paper was collected from the Northern Bay of Safaga (Egypt) which lies on the north-west side of the Red Sea some 60 km south of Hurghada (Fig. 1). The bay is approximately 10 km by 7 km and contains a mosaic of fringing reefs, coral patches, coral sand/sea grass beds, deeper muddy areas and intertidal habitats. The area has been extensively studied and detailed maps of the facies and coral biotopes are available (Piller & Pervesler, 1989; Piller & Mansour, 1990; Riegl & Piller, 1997). The details of each collecting site with quantitative samples are to be found in Zuschin & Hohenegger (1998) and their exact positions are listed in Table 1. Locality details given in the type citations and material examined sections refer to the station numbers given in Table 1.

*Sampling methods* Two methods were employed, quantitative bulk sampling (QBS in Table 1) and general collecting. Quantitative samples of various sedimentary environments and bottom facies ranging from shallow subtidal to 40 m water depth were taken by scuba diving (Table 1). A steel cylinder (diameter 35 cm) was pushed into the sediment and the uppermost 30 cm with a volume of 29 dm$^3$ was collected into a 1 mm -

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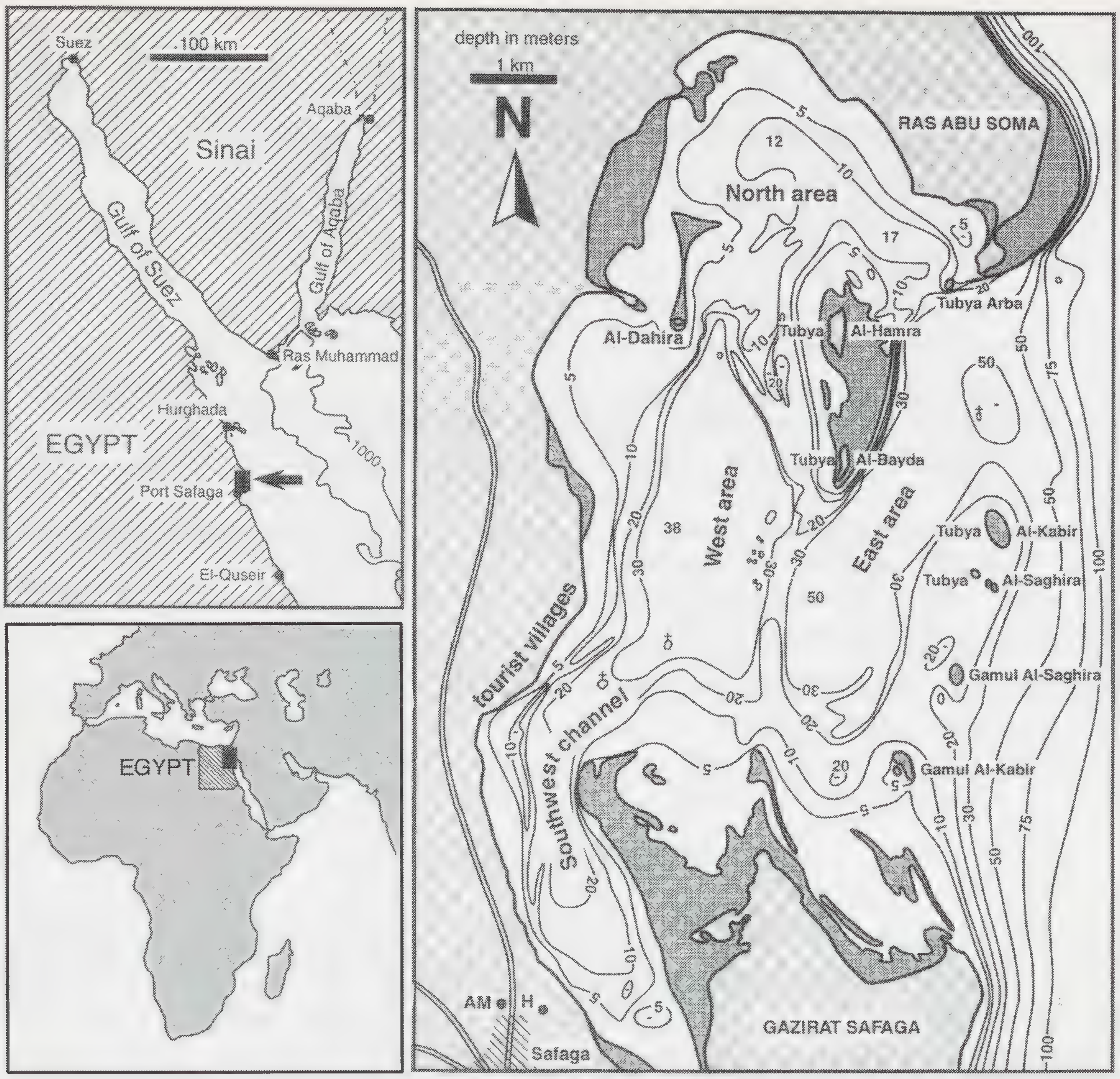


**Fig. 1** Location map and general topography of study area (after Piller & Mansour, 1990). Dark stippled fields on the larger map represent intertidal areas.

TABLE 1
Details of sampling stations in the Bay of Safaga

| Sample no. | Water depth | Bottom facies | Sample type | Position | Date |
|---|---|---|---|---|---|
| 94/1/a | 10m | sand between coral patches | QBS | 26°48.85N 33°58.61E | 25.x.1994 |
| 94/1/b | 10m | sand between coral patches | QBS | 26°48.85N 33°58.61E | 25.x.1994 |
| 94/1/c | 10m | sand between coral patches | QBS | 26°48.85N 33°58.61E | 25.x.1994 |
| 94/1/d | 10m | sand between coral patches | QBS | 26°48.85N 33°58.61E | 25.x.1994 |
| 94/3/a | 23m | muddy sand | QBS | 26°47.47N 33°56.80E | 30.x.1994 |
| 94/3/b | 23m | muddy sand | QBS | 26°47.47N 33°56.80E | 30.x.1994 |
| 94/4/a | 39m | mud | QBS | 26°48.85N 33°57.92E | 31.x.1994 |
| 94/4/b | 39m | mud | QBS | 26°48.85N 33°57.92E | 31.x.1994 |
| 94/5 | 19m | reef slope | QBS | 26°50.84N 34°0.29E | 01.xi.1994 |
| 94/6 | <1m | mangrove-channel | QBS | 26°46.05N 33°57.77E | 01.xi.1994 |
| 95/31 | 12m | reef slope | QBS | 26°49.76N 33°59.09E | 15.viii.1995 |
| B5/8 | 6m | sandy seagrass | QBS | 26°49.61N 33°57.23E | 04.xi.1986 |
| C1/3 | 40m | muddy sand with seagrass | QBS | 26°49.80N 33°59.21E | 13.vii.1987 |

mesh net. Afterwards, the sediment was air-dried and molluscs > 2 cm were removed before splitting the samples using a modified sample splitter as described by Kennard and Smith (1961). We consider the facies indicative associations (death assemblages) based on these quantitative bulk samples to be produced by the local fauna, because we have no sedimentological evidence for considerable transport, producing allochthonous assemblages. Moreover, the ecological properties of the associations match so well with the sedimentary facies (Zuschin & Hohenegger, 1998), that the species distributions are very unlikely to be a consequence of the behaviour of shells as sedimentary particles. Species described from these quantitative samples are *Limopsis marerubra* n. sp., *Semelangulus mesodesmoides* n. sp., *Leptomyaria etesiaca* (Hedley) *Abra aegyptiaca* n. sp. and *Costellipitar chordata* (Römer).

Species included from general collecting were found by divers on coral carpets (*Ctenoides concentrica* [Sowerby]) or sediments (*Offadesma sp*, *Venus toreuma* [Gould]) or by collectors searching the strandlines (*Codakia paytenorum* [Iredale]).

*Location of material* Unless otherwise cited the materials collected from the Bay of Safaga are housed in Insitut für Paläontologie, Universität Wien. The primary types and paratype series are deposited in the Naturhistorisches Museum, Wien and a second paratype series in the National Museum of Wales, Cardiff where a reference collection is also deposited.

### INSTITUTIONAL ABBREVIATIONS

| | |
|---|---|
| **BM(NH)** | Natural History Museum, London |
| **IPW** | Insitut für Paläontologie, Wien |
| **NHMW** | Naturhistorisches Museum, Wien |
| **NMW** | National Museum of Wales before 1970 |
| **NMW.Z** | National Museum of Wales, Zoology after 1970 |
| **UCZM** | University of Cambridge, Zoology Museum |

## SYSTEMATICS

### LIMOPSOIDEA
### LIMOPSIDAE

### Genus ***Limopsis*** Sassi, 1827
Type species *Arca aurita* Brocchi, 1814

### ***Limopsis marerubra*** n. sp.
Figs 2a–b

*Holotype* 1lv, Red Sea, Egypt, Bay of Safaga, IPW # 94/5, NHMW. 90656

*Paratypes* Red Sea, Egypt, Bay of Safaga– 7v, as Holotype, NHMW. 90657 2v (coated), IPW # 95/31, NHMW. 90657 6v, IPW # 95/31, NMW.Z. 1999.101.5

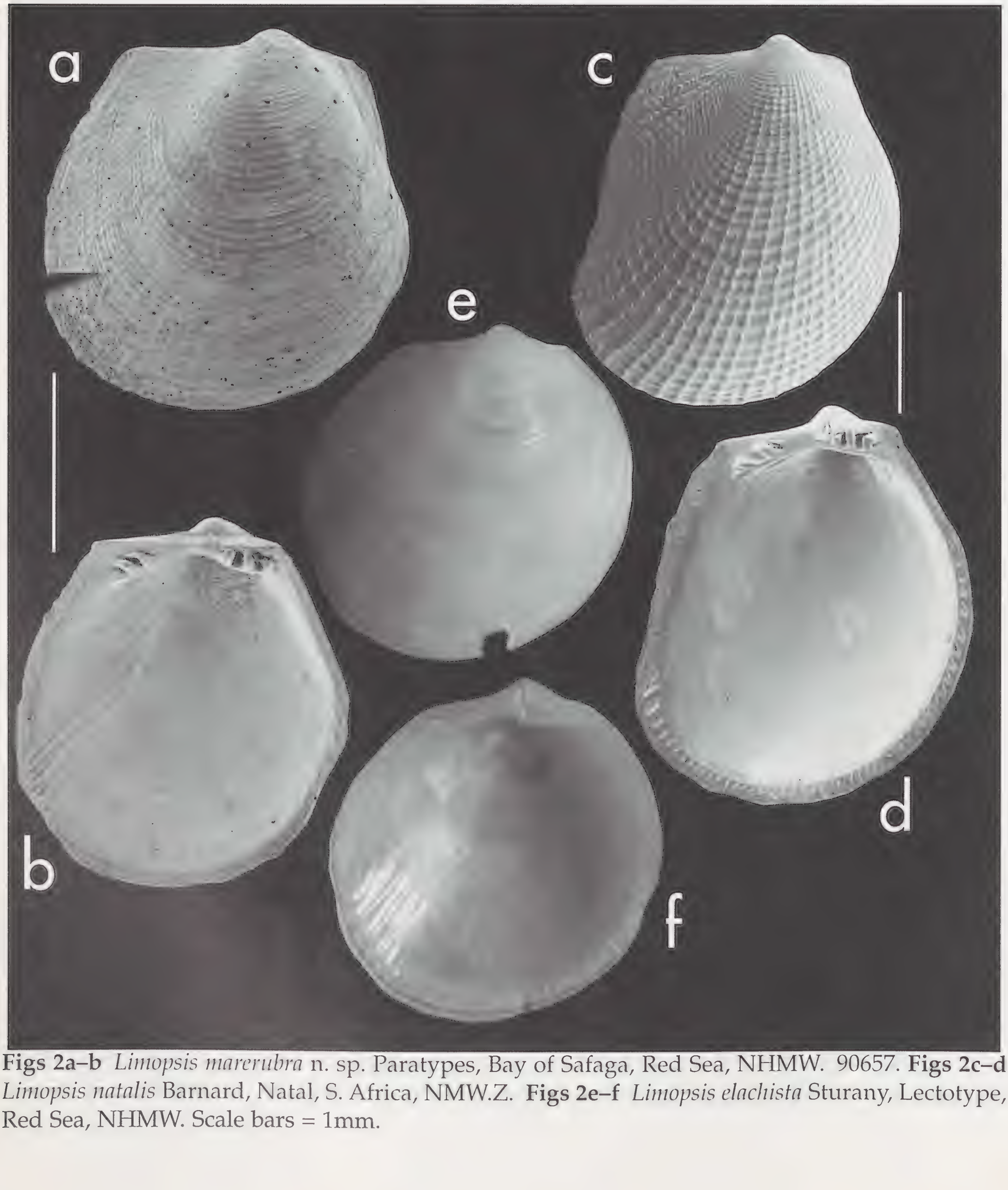
*Other material examined* Red Sea, Egypt, Bay of Safaga– 32v, IPW station 94/5, NHMW.

*Type locality* Bay of Safaga, Egypt, Red Sea.

*Measurements*

| | Mean | Std. Dev. | Std. Error | Count | Minimum | Maximum | Holotype |
|---|---|---|---|---|---|---|---|
| Height | 1.89 | | | 30 | 1.52 | 2.28 | 2.28 |
| Length | 1.77 | | | 30 | 1.45 | 2.09 | 2.07 |
| H/L | 1.07 | .03 | .006 | 30 | 1.02 | 1.16 | 1.10 |
| L/HPL | 1.69 | .15 | .028 | 30 | 1.44 | 2.09 | 2.09 |
| L/PL | 2.07 | .09 | .016 | 30 | 1.90 | 2.29 | 2.16 |

*Description* Minute to 2.5mm in height. Solid, tumid, equivalve. Outline strongly inequilateral, quadrate with a much reduced anterior dorsal area; dorsal margin long over half the width of the shell, anterior dorsal margin straight, posterior dorsal margin



**Figs 2a–b** *Limopsis marerubra* n. sp. Paratypes, Bay of Safaga, Red Sea, NHMW. 90657. **Figs 2c–d** *Limopsis natalis* Barnard, Natal, S. Africa, NMW.Z. **Figs 2e–f** *Limopsis elachista* Sturany, Lectotype, Red Sea, NHMW. Scale bars = 1mm.

slightly curved, ventral margin rounded. Sculpture of closely-spaced, radial threads intersecting concentric lines with weak beading at intersections of the two elements; anterior dorsal area with radial element becoming obsolete. Hinge taxodont, teeth in two sets divided by a small edentulous space and the ligament; anterior set of up to 3 almost vertically aligned teeth, posterior set of up to 3 slanted teeth. Ligament very small set in a shallow triangular resilium at right angles to the hinge plate. Adductor scars unequal the posterior some 5 times larger and placed close to the midline; the anterior scar is set just beneath the hinge plate. Inner margin weakly crenulate except for 3–5 prominent crenulae ventral to the posterior adductor scar. Shell white, tinged with amber or occasionally with amber and pink

*Derivation of name* *marerubra* from the Latin for **Red Sea**, the type locality.

*Habitat* Dead disarticulated valves only were found in sediments from *Porites* dominated and *Millipora*/*Acropora* dominated reef slopes from 12 and 19m. Although found only as valves the form of the shell suggests (Oliver, 1981) that it lives epifaunally attached by the byssus probably under coral debris or in crevices in the reef itself.

*Distribution* Known only from the Red Sea from the Bay of Safaga.

*Remarks* *Limopsis marerubra* belongs to a small but distinct group of limopsids typified by their quadrate outline (Morphological Class VIII after Oliver, 1981). Belonging to this group are the Recent species *L. natalis* Barnard, 1964, *L. antillensis* Dall, 1881, and the European Tertiary fossil species *Limopsis* (as *Pectunculus*) *pygmaeus* Philippi, 1836.

From the only other Indian Ocean taxon, *L. natalis* (Figs 2c–d), *L. marerubra* differs in being relatively more inflated, and in having a more dense sculpture which does not form distinct nodules at the intersections of the radial and concentric elements. *Limopsis elachista* Sturany, 1899 (Figs 2e–f) and *L. elachista* non Sturany, Melvill & Standen, 1907 although small do not have the distinctly truncated dorsal anterior margin and have more uniform marginal crenulations.

## LIMOIDEA

## LIMIDAE

### Genus *Ctenoides* Mörch, 1853

Type species *Ostrea scabra* Born, 1778

### *Ctenoides concentrica* (Sowerby, 1888)

Fig. 3

*Lima concentrica* G.B. Sowerby II, 1888: 207, fig 20.
*Lima oshimiensis* G.B. Sowerby II, 1914: 38.
*Ctenoides concentrica*– Matsakuma, Okutani & Habe, 1991: pl. CXLIII, fig 6.
*Ctenoides concentrica*– Bernard, Cai & Morton, 1993: 43.

*Material examined* Red Sea, Bay of Safaga, 1v, near to IPW#97/16, 34m, 01.iv.1997. Japan, Holotype of *L. oshimiensis*, Oshimi, BM(NH) 1915.1.6.203.

*Type locality* Hong Kong.

*Description of Red Sea shell* 44.9 mm in height, fragile and thin, moderately compressed.

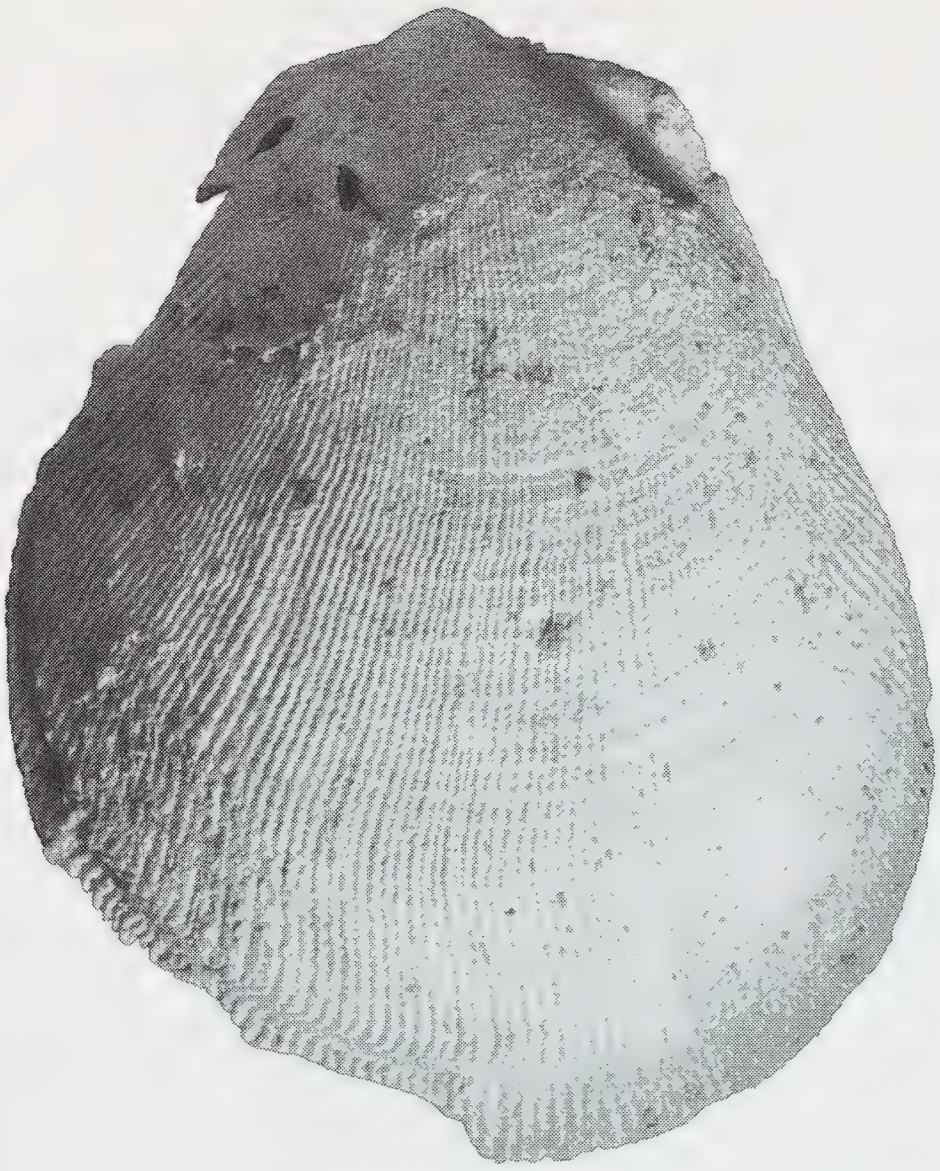


**Fig. 3** *Ctenoides concentrica* Sowerby. Single valve from Bay of Safaga, Red Sea, Actual size 44.9 mm high.

Almost equilateral. Auricles small, subequal. Outline ovoid widest across the median point. Sculpture of numerous closely-spaced, raised, radial riblets these becoming sinuous over the median ventral area and overall weakly interrupted by evenly spaced concentric threads.

*Habitat* The single poorly preserved valve was found among a Faviid carpet community at 34 m. In the literature references cited above, offshore muddy sediments are recorded.

*Distribution* East China Sea, Taiwan, Okinawa to Honshu, Japan (Bernard *et al*, 1993) and the Red Sea. The Red Sea shell is the first record of this species beyond its South and East China Sea range.

*Remarks* In the modern literature (Bernard *et al*, 1993; Matsakuma *et al*, 1991) *L. oshimiensis* is cited as a junior synonym of *L. concentrica* but we note that the type of *L. concentrica* could not be found in the Natural History Museum, London. The original figures of both taxa are poor and we hesitate to confirm the synonymy but we are certain that the Red Sea shell is very like the type of *L. oshimiensis*. This species is apparently very rare and along with its fragility may account for the absence of records.

Although this species is now assigned to *Ctenoides* the anterior aperture lip formation is rather weak and the sculpture is wavy-radial rather than scabrous. In outline however the affinity is with *Ctenoides*.

## LUCINOIDEA
## LUCINIDAE

### Genus ***Codakia*** Scopoli, 1777
Type species *Chama codok* Adanson, 1757 = *Venus orbicularis* L., 1758

Among the samples of *Codakia* collected from the Bay of Safaga and originally presumed to be varietal shells of *C. tigerina* (L, 1758) are six valves and one shell which do not possess the nodulose sculpture typical of that species. These specimens however are more strongly sculptured, especially on the lateral areas than the other common western Indian Ocean species, *C. punctata* (L., 1758). Given the limited material at hand the problem of their identity seemed unresolved until the presence of Iredale's species, *C. paytenorum* was brought to our attention by Dr. John Taylor. This species which Iredale describes as being intermediate between *"exasperata"* (= *tigerina*) and *"simplex"* (= *punctata*) was originally described from Queensland. It has now been noted to extend westward to Sri Lanka (J. Taylor pers. comm.) and therefore its presence in the Red Sea is not surprising. A brief diagnoses of the Red Sea shells is given and comparisons with *C. tigerina* and *C. punctata* are illustrated (Figs 4b–c).

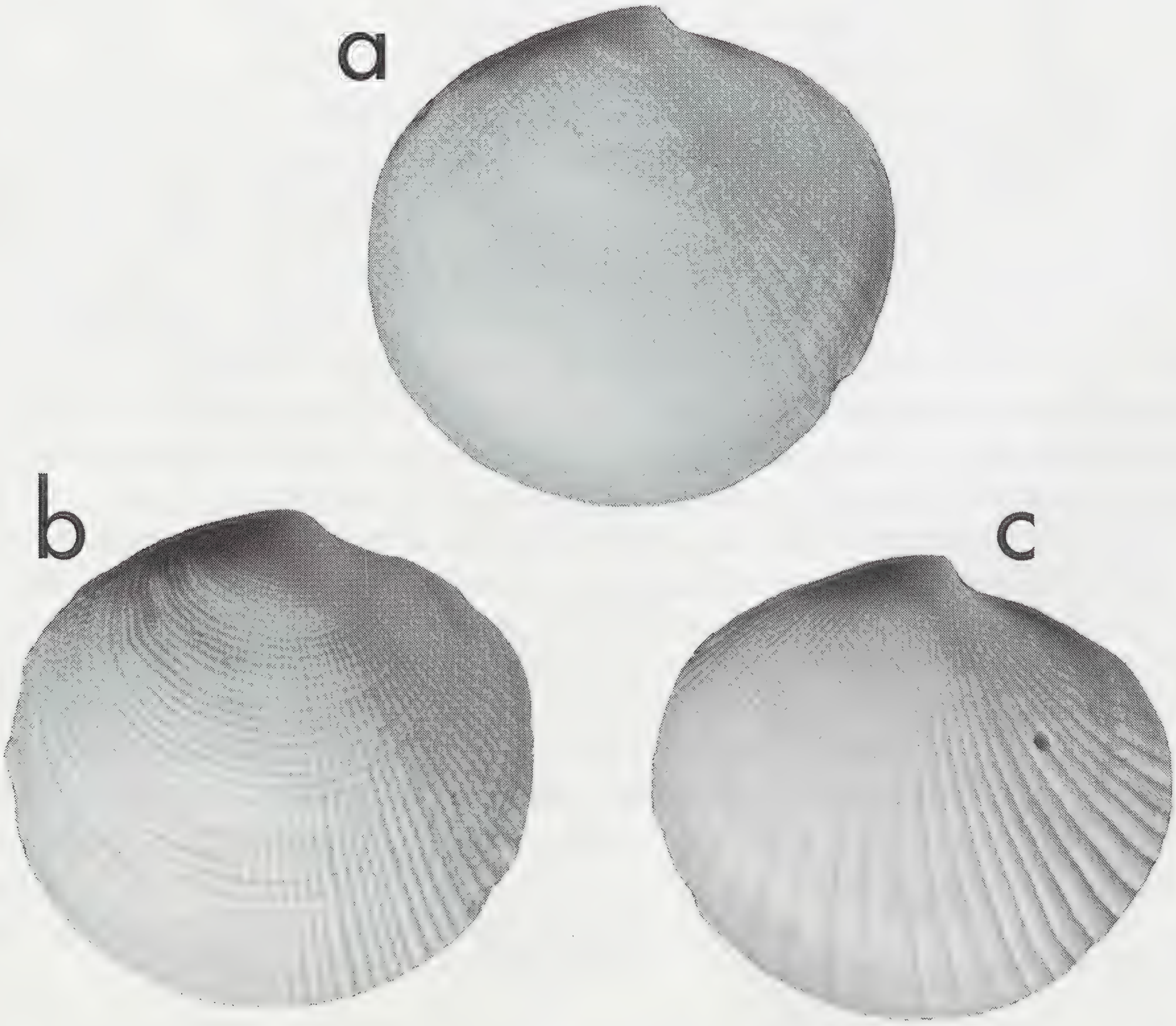
### ***Codakia paytenorum*** (Iredale, 1937)

Fig. 4a

*Lentillaria paytenorum* Iredale, 1937: 240, pl. xvi., figs 2, 3.

*Material examined* Red Sea, Egypt, Bay of Safaga: 1rv, Al Dahira, 26°50′N 32°57.5′E, Drift line, 30.iii.1997, PGO, NMW.Z.1997.21.68. 1sh, North of Safaga Id, near to IPW #96/26, 28.v.1996. 1rv, IPW#94/1/a. 2rv+2lv, IPW#C1/3

*Type locality* Lord Howe Island.



**Figs 4a–c. a** *Codakia paytenorum* Iredale Bay of Safaga, Egypt, NMW.Z.1997.21.68, 34.5mm. **b** *Codakia tigerina* (L.) Malindi, Kenya, NMW.1955.158, 34.7mm. **c** *Codakia punctata* (L. ) Seychelles, NMW.1925.170, 34mm.

*Remarks* The largest Red Sea shell is 35 mm length (type is 54 mm). Both *C. tigerina* and *C. punctata* can attain a much larger size to 80 mm. Outline subcircular slightly longer than high but not different from *C. tigerina*. Sculpture of fine concentric ridges crossed by closely spaced radial striae on the lateral areas and by wider spaced weak grooves medially. The sculptural intersections are weakly nodulose only on the extreme dorsal-lateral areas, subcancellate on the remaining lateral areas and not raised medially. In *C. tigerina* (Fig. 4b) the sculptural intersections are all distinctly nodulose and in *C. punctata* (Fig. 4c) the radial element is as grooves over the whole shell so that not even the lateral areas are rough. The sculptural differences are expressed on the internal margin so that *C. tigerina* is crenulate all round, whereas *C. paytenorum* is ventrally smooth with traces of crenulae dorso-laterally. The hinge and ligament form is the same in each species as is the general colour pattern of a yellow interior with a deep rose margin at least over the hinge and dorsal margins. It appears that *C. tigerina* in the Red Sea more frequently has reduced marginal colouration to the extent that it may only be seen on the lunule.

*Habitat* From the material at hand it is not possible to comment on the ecological preferences of the two *Codakia* species present in the Bay of Safaga. Shells of both are found in association with coral sand or sea grass facies but any depth or community preferences are not known. The anterior adductor scar length which indicates depth of burrowing is the same in both which further indicates that the species are sympatric.

## TELLINOIDEA

## TELLINIDAE

The family definitions within the Tellinoidea remain largely centred on the form of the ligament and hinge teeth such that the Semelidae are recognised by the internal ligament which is set on a spoon shaped chondrophore and the Tellinidae in having an external ligament on a prominent nymph. As early as 1885 Jeffreys (in Smith, 1885) discussed with Smith the presence of a small internal ligament in some typical tellins. This internal portion may only be present in juveniles as in *Tellina donacina* or persist into adulthood as in *Tellina tenuilirata*. The extent of the ligament in the latter was sufficient for Iredale (1924) to create the genus *Semelangulus*. The addition of *Ervilia* to the Tellinoidea (Morton & Scott, 1990) further confuses the family distinctions as the ligament although internal does not sit on a spoon shaped chondrophore.

This study includes three tellinoid species all with the primary ligament set internally but having either a small external ligament or lacking the spoon shaped chondrophore typical of the Semelidae. The generic placement of these taxa is consequently difficult because they neither fall into typical tellinid genera nor into typical semelid genera. The association of small internal ligaments with many juvenile tellinids suggests that in small or minute species this may be retained into adulthood. If so this feature cannot be used to associate these taxa preferentially with the Semelidae as they could equally be interpreted as neotenous tellinids. This paper is not a review of the generic and family levels of the Tellinoidea and we hesitate to erect new generic taxa here. Instead we place these new species to the most similar existing genus but realising that in doing so we are extending the scope of the generic definitions.

### Genus *Semelangulus* Iredale, 1924
Type species *Tellina tenuilirata* Sowerby, 1868 .

### ***Semelangulus mesodesmoides*** n. sp.
Figs 5a–d

*Tellina opalina* non Sowerby, 1866– Hedley 1899: 499, Fig. 52.

*Holotype* 1 right valve, Red Sea, Egypt, Bay of Safaga, IPW#95/31, NHMW. 90658.

*Paratypes* Red Sea, Egypt, Bay of Safaga, – 1rv, as Holotype, NHMW.90659. 1rv, as Holotype, NMW.Z.1999.101.6 1rv, IPW #94/1/a, NHMW.90659. 1rv, IPW# 94/1/a, NHMW.90659. 1lv, IPW# 94/1/d, NHMW.90659. 1lv, IPW# 94/1/d, NMW.Z.1999.101.7 1lv, IPW#94/1/c, NHMW.90659. 1lv, IPW# 94/1/c, NMW.Z.1999.101.8.

*Other material examined* Red Sea, Egypt, Bay of Safaga, – 10v, IPW#94/1/a. 9v, IPW#94/1/b. 8v, IPW#94/1/d. 10v, IPW#95/31.

*Type locality* Bay of Safaga, Egypt, Red Sea.

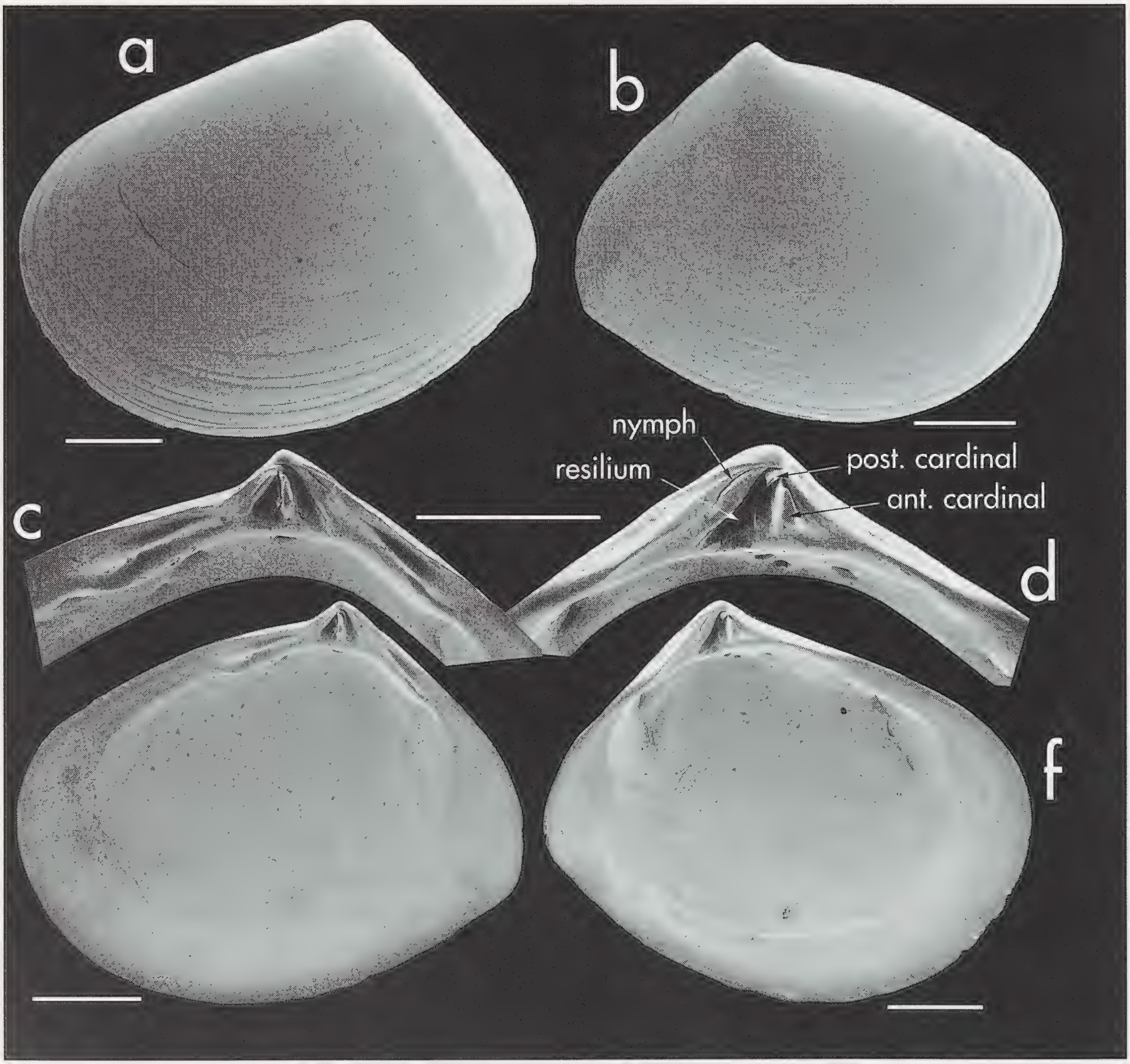
*Measurements*

| | **Mean** | **Std. Dev.** | **Std. Error** | **Count** | **Minimum** | **Maximum** | **Holotype** |
|---|---|---|---|---|---|---|---|
| Length | 4.04 | | | 18 | 2.32 | 6.51 | 5.5 |
| Post. Length | 1.398 | | | 18 | 0.78 | 2.31 | 1.91 |
| Height | 2.82 | | | 18 | 1.69 | 4.40 | 3.73 |
| L/PL | 2.88 | 0.19 | 0.045 | 18 | 2.67 | 3.36 | 2.88 |
| L/H | 1.42 | 0.06 | 0.014 | 18 | 1.34 | 1.52 | 1.48 |

*Description* To 8 mm in length. Solid. Slightly inequivalve, lv more inflated and posteriorly twisted. Strongly inequilateral, L/PL = mean 2.88. Beaks well behind the midline, weakly directed anteriorly. Outline subovate, anterior expanded and broadly rounded, posterior narrowed, roundly acute, posterior slope narrow and weakly defined. Sculpture smooth with weak growth lines. Hinge: rv with 2 narrow laminar cardinals in front of beak and single anterior and posterior socketed laterals set close to the beaks; lv with 2 cardinals the anterior one large and projecting, the posterior one laminar and often eroded by encroachment of the resilifer; single anterior and posterior laterals present as extensions of the dorsal margin, these giving the appearance of the presence of a lunule and escutcheon in the lv only. Ligament mostly internal set on a narrow resilifer which does not project beyond the hinge plate; external ligament one fifth the length of the internal and set on a narrow sunken nymph. Adductor scars subequal. Pallial sinus very large, wedge-shaped and extending to the anterior pallial line just below the anterior adductor scar and confluent from this point; dorsal line more or less straight, running diagonally from point of confluence to the mid point of the posterior adductor. Inner margin smooth. Colour white with maculations formed by opaque and semihyaline regions of the shell.

*Derivation of name* *mesodesmoides* from the genus *Mesodesma* and the latin suffix *oides* which means to resemble. Refers to the outward similarity of the shell to small species of *Mesodesma*.

*Habitat* The facies type was predominantly coral sand between coral patches at around 10 m.



**Figs 5a–d** *Semelangulus mesodesmoides* n. sp. Paratypes. Bay of Safaga, Egypt. Scale bars = 1mm.

*Distribution* Known only from Funafuti, Tuvalu (Ellice Ids) in the south central Pacific and the Red Sea. Probably distributed throughout the Indo-Pacific in coral sands but overlooked because of its small size.

*Remarks* Species level similarities are few and only the figure given by Hedley (1899) but labelled *Tellina opalina* can safely be regarded as conspecific. *Tellina opalina* is a larger less wedge shaped species with a typical tellin hinge lacking an internal ligament. An obvious and distinctive feature of *S. mesodesmoides* is the curious pattern of opaque and semi-transparent shell zones and this can also be seen in *Tellina crebrimaculata* Sowerby, 1868 and *T. fijiensis* Sowerby, 1868. Examination of the type series (BM(NH) 1856.11.3.31–32) revealed that *T. crebrimaculata* belongs to the genus *Cadella* and has no internal ligament. The type of *Tellina fijiensis* (BM(NH) 1856.9.24.125) is a striking shell of a deep pink hue and bold maculations with a hinge structure similar to that of *S. mesodesmoides* and clearly congeneric with it. The internal ligament is prominent but only a little over half the size of the external ligament (Int:Ext = 1:2) and in contrast to that of *S. mesodesmoides* in which the internal portion is the larger (Int:Ext = 4-5:1). In *T.*

*fijiensis* the shell is more compressed and there is no obvious difference between the left and right valves; the posterior slope is less steep but there is a more obvious suture to the anterior side of the posterior angle; the sculpture is distinctly lirate.

On first appearances the greatly shortened posterior area gives *S. mesodesmoides* a closer resemblance to mesodesmatids and donacids than to small tellins. Internally the very large pallial sinus and hinge characters ally this form to the Tellinidae except that the ligament has a large internal element. The internal ligament is set on a narrow resilifer that does not project beyond the hinge plate and is oriented more or less vertically. The ligament is therefore not like those of typical Semelidae or *Ervilia.* There is a small external ligament sitting on a sunken nymph which allies this form to the genus *Semelangulus.* However, the relative proportions of the internal and external ligaments are reversed in the type species of *Semelangulus* (*Tellina tenuilirata*, BM(NH) 1877.5.12.75) such that the external part is some five times larger than the internal (Int:Ext = 1:5). *Tellina fijiensis* is intermediate in the form of the ligament but shares with *S. mesodesmoides* the shortened but strengthened form of the lateral teeth. In *S. tenuilirata* the lateral teeth are long and narrow especially the anterior which runs beside most of the anterior dorsal margin. Without an extensive revision we cannot resolve the generic confusion and therefore place all of these tellin shaped forms with a distinct internal resilium plus an external nymph in the genus *Semelangulus.*

## SEMELIDAE

### Genus **Leptomyaria** Habe, 1960

Type species *Leptomyaria trigona* OD

### ***Leptomyaria etesiaca*** (Hedley, 1909)

Figs 6a–d

*Tellina etesiaca* Hedley, 1909: 431,pl. 38. figs. 30–32.

*Holotype* In Australian Museum Sydney (not examined).

*Material examined* Queensland– Co-types 6v, Hope Islands, 5–10fms, leg Hedley, BM((NH) 1910.9.28.60–65. Topotypes? 5v, Cairns Reef, E of Hope Islands, leg Gabriel (part of original collecting expedition), NMW.Z.1955.158. Red Sea, Egypt, Bay of Safaga: 35v, IPW#94/3/a. 54v, IPW# 94/3/b. 19v, IPW#94/4/a. 27v, IPW#94/4/b. 4sh, Gulf of Suez, leg. Macandrew, UCZM.

*Type locality* Queensland, Australia– Hope Islands, Gt. Barrier Reef, 16°N.

*Measurements*

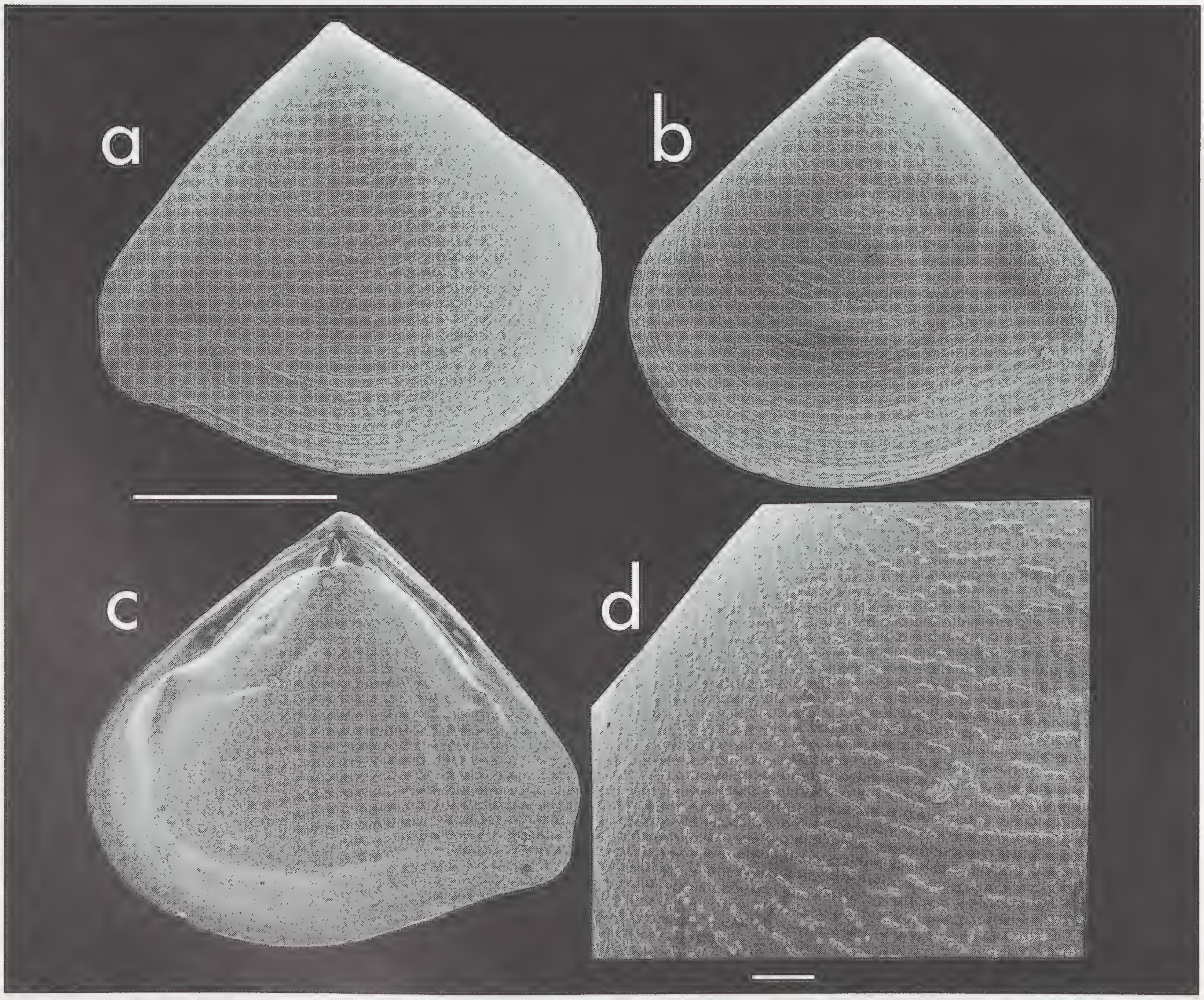
| | **Mean** | **Std. Dev.** | **Std. Error** | **Count** | **Minimum** | **Maximum** |
|---|---|---|---|---|---|---|
| Height | 1.58 | | | 30 | 1.27 | 2.07 |
| Length | 1.99 | | | 30 | 1.59 | 2.64 |
| L/H | 1.26 | .05 | .008 | 30 | 1.14 | 1.35 |
| Umbo angle | 109 | 3.54 | .646 | 30 | 100 | 118 |

*Description* Minute to 3 mm. Translucent, fragile not noticeably inequivalve, lv dorsal margins fitting into rv lateral sockets. Slightly inequilateral, anterior a little more pronounced. Outline trigonal, dorsal margins long and straight, anterior and anterior ventral in a broad curve, posterior narrow, subtruncate, posterior ventral with a weak sinus. Anterior dorsal area weakly depressed to form an elongate lunule. Sculpture smooth but most shells with an interrupted concentric sculpture of short rows of minute spheroidal beads; posterior area narrow slightly sulcate and demarcated by a rounded radial ridge. Hinge: rv with 2 small cardinal teeth the posterior much larger and projecting, anterior and posterior socketed lateral teeth strong running the whole length of each dorsal margin; lv with 2 cardinal teeth, anterior large and projecting, posterior laminar and becoming obsolete by encroachment of the ligament, lateral teeth as projections of the dorsal margins. Ligament internal set on a small almost vertically aligned resilifer which does not project beyond the hinge plate. Adductor scars subequal, the posterior larger and rectangular in outline, the anterior narrowly oval. Pallial sinus deep reaching to a point below the distal end of the anterior lateral tooth, confluent with the pallial line from a point just anterior to the midline below the beak. Colour white.

*Habitat* The facies type was predominantly muddy sand without sea grass at around 20m.

*Distribution* Known only from Queensland and the Red Sea but is probably widespread in muddy sediments associated with reef lagoons throughout the Indo-Pacific.

*Remarks* Originally described as a *Tellina* this minute species has a ligament set entirely on an internal resilifer and probably belongs to the Semelidae. The resilifer, however, is not oblique and does not extend beyond the hinge plate and in this respect differs from the typical semelid chondrophore. In outline it is reminiscent of a tiny *Leptomya* but not



**Figs 6a–d** *Leptomyaria etesiaca* Hedley, Bay of Safaga, Red Sea. **a** left valve external. **b** right valve external. **c** left valve internal. Scale bars = 1 mm. **d** detail of sculpture. Scale bar = 100 µm.

of *Abra* or *Theora*. Unlike *Leptomya* it has a very deep pallial sinus and is not subrostrate only narrowly truncate. *Leptomyaria* species are variable but some are subtrigonal with a deep pallial sinus and long lateral teeth. For the present we have assigned *Tellina etesiaca* to this genus but it does not lie easily with any current generic definitions.

The shells collected by Macandrew in 1869 were never identified and were not mentioned in his paper (1870). His specimens remained un-noticed for 130 years and consequently delayed the recognition of this taxon from the Red Sea!

### Genus *Abra* Lamarck, 1818

Type species *Mactra tenuis* Montagu, 1818

### **Abra aegyptiaca** n. sp.

Figs 7a–c

*Holotype* 1lv, Red Sea, Egypt, Bay of Safaga, IPW#94/4/b, NHMW. 90660.

*Paratypes* Red Sea, Egypt, Bay of Safaga: 3lv+3rv, IPW#C1/3, NHMW. 90661 1lv, IPW#94/4/b, NMW.Z. 1lv, IPW#94/4/a, NMW.Z. 4v, IPW#C1/3, NMW.Z.1999.101.9.

*Material examined* Red Sea, Egypt, Bay of Safaga: 5v, IPW#94/3/a. 1v, IPW#94/3/b. 3v, IPW#94/4/a. 1v, IPW#94/4/b. 13v, IPW#C1/3.

*Type locality* Bay of Safaga, Egypt, Red Sea

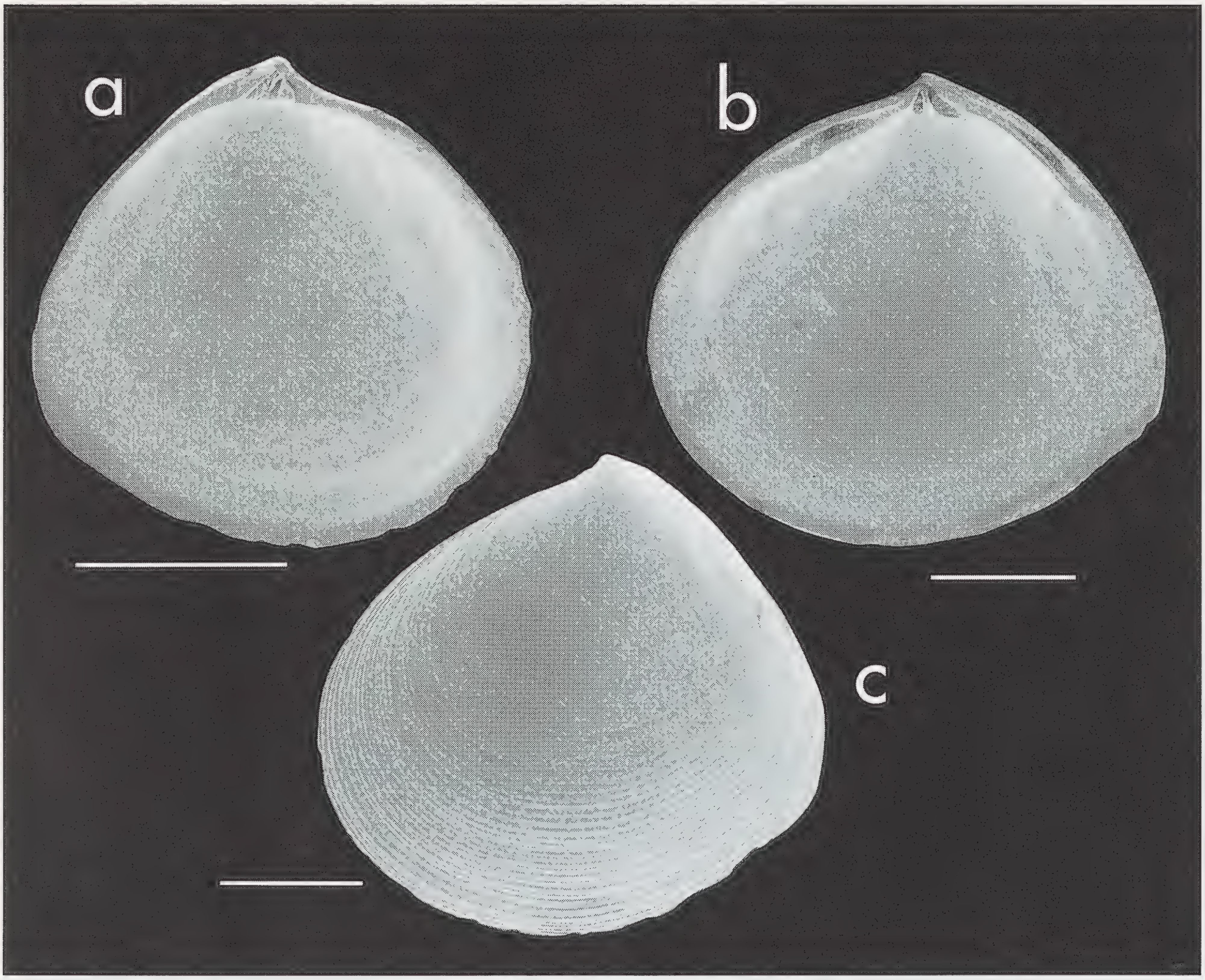
*Measurements*

| | **Mean** | **Std. Dev.** | **Std. Error** | **Count** | **Minimum** | **Maximum** | **Holotype** |
|---|---|---|---|---|---|---|---|
| Length | 2.91 | | | 30 | 1.76 | 3.89 | 3.21 |
| Height | 2.39 | | | 30 | 1.49 | 3.11 | 2.56 |
| L/PL | 2.25 | .19 | .034 | 30 | 1.88 | 2.56 | 2.03 |
| L/H | 1.21 | .04 | .007 | 30 | 1.16 | 1.31 | 1.25 |

*Description* Shell to 4 mm. Thin, fragile, compressed. Slightly inequilateral, beaks just behind the midline. Outline subcircular - subovate, whole of anterior and anterior ventral margins broadly rounded, posterior dorsal slope long and very slightly curved, posterior roundly subacute, posterior ventral margin weakly sinuous. Lunule, a small shallow depression. Sculpture smooth with growth lines and weak concentric threads; posterior slope narrow and weakly defined by a radial ridge. Hinge: rv with 2 cardinal teeth, the posterior larger and projecting; prominent socketed posterior and anterior lateral teeth present, the anterior shorter and thicker; lv with 2 cardinal teeth, the anterior larger and projecting, the posterior laminar and becoming obsolete by encroachment of the chondrophore; lateral teeth present as extensions of the anterior and posterior margins. Ligament internal, set on a distinct spoon shaped resilifer which set obliquely to the hinge plate but does not project beyond it. Adductor scar subequal the posterior rectangular in outline, the anterior narrowly oval. Pallial sinus very large, following the curve of the pallial line and extending close to the anterior adductor to a point below the distal end of the lateral tooth; only confluent with the pallial line from a point below the beak. Colour white

*Derivation of name* *aegyptiaca* from the type locality Egypt.

*Habitat* The facies types are mostly muddy sand with sea grass below 20 m. Such



**Figs 7a–c** *Abra aegyptiaca* n. sp. Paratypes, Bay of Safaga, Egypt. Scale bars = 1 mm.

muddy sediments are typical for *Abra* species which are deposit feeders.

*Distribution* Known only from the type locality but is probably widely distributed throughout the Indo-Pacific in sheltered muddy embayments.

*Remarks* The form of *A. aegyptiaca* is reminiscent of the *Abra / Theora* group of taxa except that the outline is subcircular and the resilifer is neither extended posteriorly nor projects beyond the hinge plate. Some species of *Abra* have a rounded form such as *A. aequalis* from the east coast of southern USA but the species we have examined of *Abra, Syndesmya* and *Theora* all have a strongly developed chondrophore extending obliquely beyond the hinge plate.

Species level comparisons are few as most Indo-Pacific species have a less rounded subovate outline and the large chondrophore. We have examined figures or specimens of *A. fujitae* Habe, 1958; *A. kurodae* Habe, 1961; *A. (Abrina) lunella* Gould, 1861; *A. inanis* Prashad, 1932; *A. sibogai* Prashad, 1932; *Syndosmya cistula* Melvill & Standen, 1907 and *Semele infan*s Smith, 1885 but none warrant detailed comparison as they do not compare in outline.

## VENEROIDEA
## VENERIDAE
## PITARINAE

### Genus **Costellipitar** Habe, 1951
Type species *Caryatis chordata* Römer, 1869

### ***Costellipitar chordatum*** (Römer, 1869)
Figs 8a–d

*Caryatis chordata* Römer, 1869: 125, pl. 33, fig. 2–2b
*Costellipitar chordatum* Römer– Habe, 1977: pl. 53, figs 14–16

Note: Some illustrations in Habe, 1977 have misplaced legends; relevant to this paper is the reversal of figures 14–16 and 19–21. Figs 14–16 should be labelled *Costellipitar chordatum* and Figs 19–21 *Microcirce dilecta.*

*Material examined* Red Sea, Bay of Safaga: 101v, IPW #94/4/a. 79v, IPW#94/4/b.

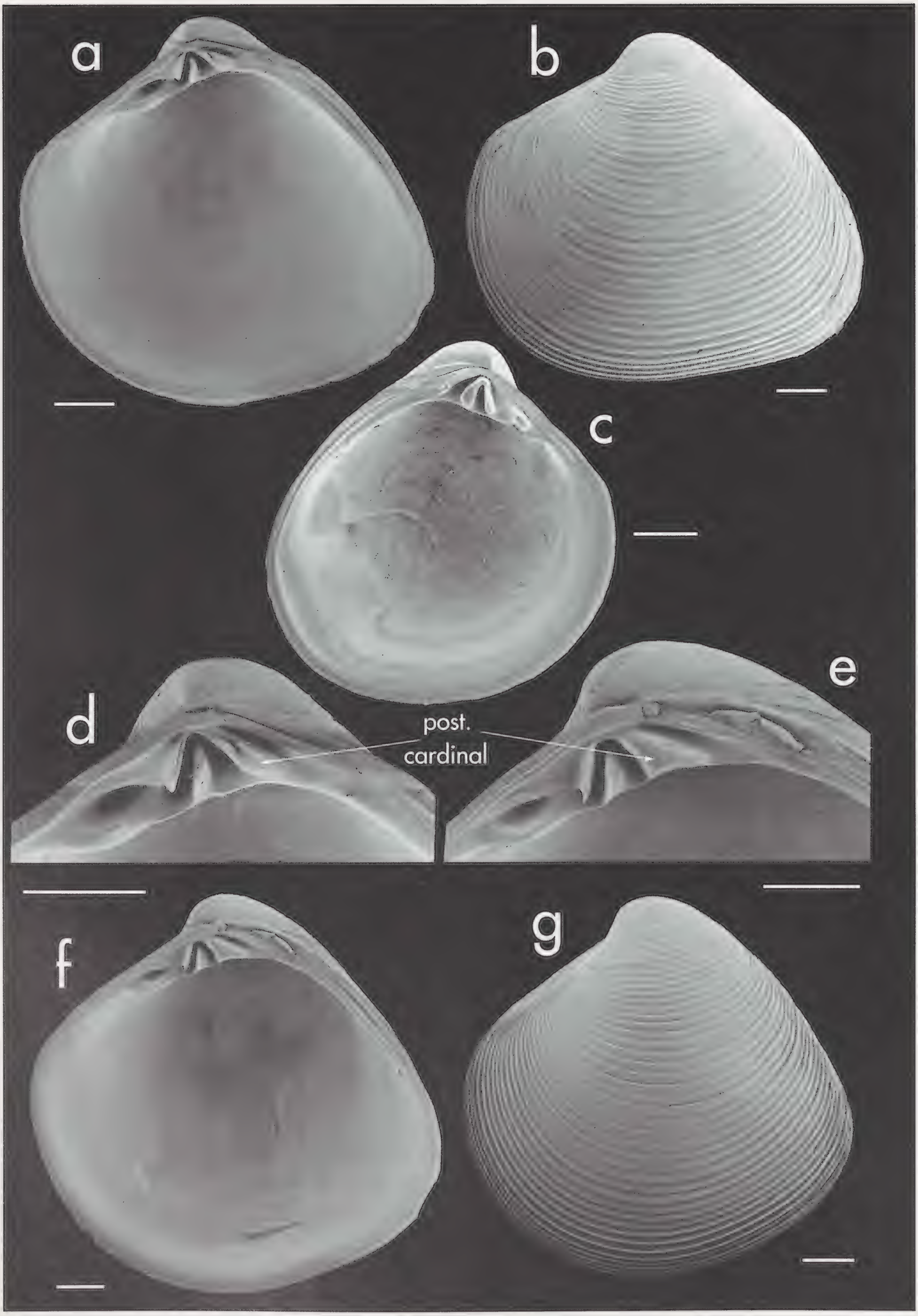
*Type locality* Not known.

*Measurements*

| | **Mean** | **Std. Dev.** | **Std. Error** | **Count** | **Minimum** | **Maximum** |
|---|---|---|---|---|---|---|
| Length | 5.67 | | | 40 | 2.55 | 9.74 |
| Height | 4.45 | | | 40 | 2.16 | 6.95 |
| Post. Length | 3.90 | | | 40 | 1.64 | 6.81 |
| L/H | 1.26 | .064 | .010 | 40 | 1.14 | 1.40 |
| L/PL | 1.46 | .054 | .009 | 40 | 1.37 | 1.56 |

*Description of Red Sea shells* Shell to 11 mm, solid, a little inflated with prominent umbos, equivalve. Inequilateral with beaks distinctly in front of midline, outline trigonally suboval, anterior broadly rounded, ventral gently curving but becoming straight or slightly sinuous especially towards the posterior ventral; posterior dorsal margin long weakly curved and sloping steeply, posterior margin narrowly rounded. Lunule large narrowly cordate and demarcated by an incised line. Escutcheon obscure. Sculpture of evenly spaced narrow concentric ridges with a density of 4–6 per millimetre on larger shells, all over with fine concentric growth lines. Surface microscopically pitted (visible only under SEM). Hinge strong, teeth large: rv with 3 radiating cardinal teeth, the posterior the largest and weakly bifid, central tooth not joined dorsally to hinge plate; a single socketed anterior lateral tooth is situated close to the cardinal complex; lunule margin with narrow groove along its length and a similar groove on the margin of the posterior dorsal slope;lv with 3 cardinal teeth the posterior much weaker, laminar and becoming obsolete, anterior pair joined dorsally forming an inverted V-shape; anterior lateral tooth a single projection corresponding to the rv socket; corresponding marginal ridges to lv grooves present. Ligament present on a short shallow nymph. Adductor scars subequal; pallial sinus of moderate depth, prominent, openly rounded, moderately ascending and reaching a point below the posterior cardinal tooth; never confluent with pallial line. Inner margin smooth. Colour white.

There is a distinct change of shape with growth from being rounded in the juvenile to becoming more inequilateral, more trigonally suboval and finally developing a straight to sinuous ventral margin.



**Figs 8a–d** *Costellipitar chordatum* Römer, Bay of Safaga, Egypt, IPW #94/4/a.
**Figs 8e–g** *Cytherea minuta* Koch fide Lynge, 1909, Thailand. Scale bars all = 1mm.

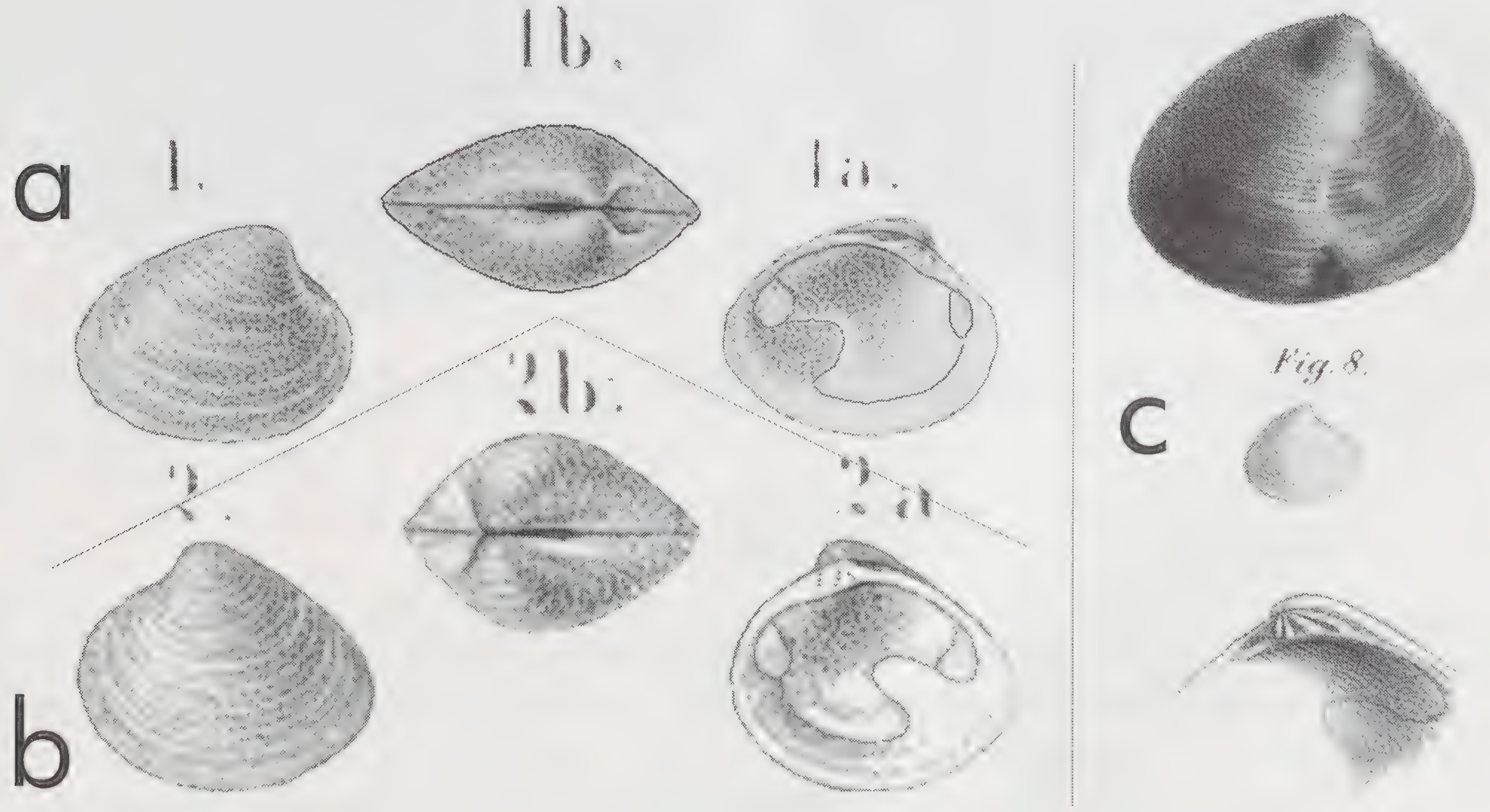
*Habitat* The only facies was mud at 40 m.

*Distribution* Throughout the Indo-Pacific from Japan to the Red Sea but not recorded from Australia.

*Remarks* The absence of type material (both Römer's and Koch's collections have been lost) makes an assessment of this taxon problematic. Lynge (1909) noted the difficulties of relying on the original figures but did assign his Gulf of Thailand material to *Cytherea minuta* Koch and suspected that *C. chordata* Römer was a synonym. A very similar form is illustrated by Habe (1977) and named as *C. chordata* and this was given as the type species of *Costellipitar* Habe, 1951.

The original figures of Römer (1869) (Fig. 9a) and Koch in Philippi (1845) (Fig. 9c) are reproduced here and do show very similar forms. The figures in Philippi are poor but the comparative illustrations of *C. minuta* given by Römer (Fig. 9b) indicate slight differences in outline and the form of the pallial sinus. The material examined by Lynge [Danish Expedition to Siam (Thailand): 10v, c. 15 Korul V. f. Koh Kut, 30fms. 1v, S f. Koh Kakdat, 8–10fms. 3sh + 4v, c.12 k f. Koh Mak, 20fms. Singapore last Vand. Konsul sv Gad.] although very similar to the Red Sea shells differs as follows (Figs 8e–g). The straightened ventral margin does not develop; the lunule margin is slightly raised rather than flattened; the posterior cardinal tooth is more prominently bifid and the pallial sinus is narrower and more steeply angled.

It therefore appears that two species do exist and that the name *C. chordatum* can best be applied to the Red Sea material. A wide revision and designation of lectotypes is needed for this group and it should be noted that the *C. minuta* Koch is preoccupied by *Cytheria minuta*, Brown 1927.



**Figs 9a–c** **a** *Cytherea chordata* from Römer, 1869. **b** *Cytherea minuta* from Römer, 1869. **c** *Cytherea minuta* from Philippi, 1845.

### VENERINAE

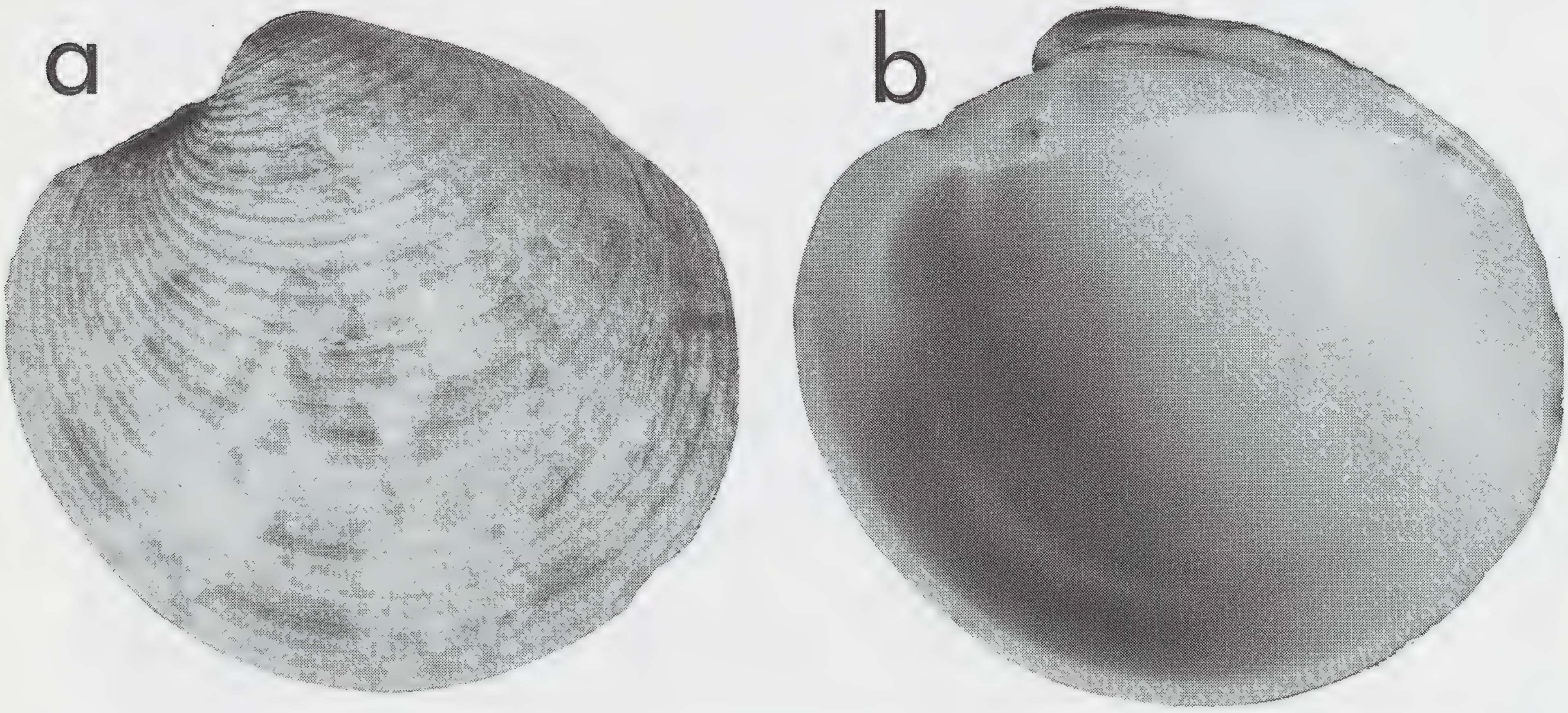
Genus ***Ventricolaria*** Linnaeus, 1758
Type species *Venus*; SD Gray, 1847

***Ventricolaria toreuma*** Gould, 1850
Figs 10a–b

*Ventricolaria toreuma* Gould- Singer & Mienis, 1995: 9–11.

*Material examined* Red Sea, Bay of Safaga: (1sh +1v in Cardiff). 1v, IPW north of Al Hamra, 5m, 1995. 1v, IPW #B15/1, north of Safaga Id, 28m, 18.ii.1987. 1v, near to IPW#97/16, north of Tubya al Kabir, 01.iv.1997. 1v, IPW#95/38. 1v, IPW#95/23.

*Ventricolaria toreuma* was first recorded from the Red Sea as recently as 1995 (Singer & Mienis, 1995). Dead valves were frequently encountered in the Bay of Safaga, mostly from coral sand facies. *V. toreuma* is widely distributed throughout the Indo-Pacific.



**Figs. 10a–b** *Ventricolaria toreuma*. Bay of Safaga, Red Sea, Egypt. Actual size = 37mm.

### PANDOROIDEA
### PERIPLOMATIDAE

Genus ***Offadesma*** Iredale, 1930
Type species *Periploma angasi* Crosse & Fischer, 1864

**Offadesma** sp.
Fig 11a

*Material examined* 1rv, IPW# at 26°48.35'N 33°58.47'E, 52m, 30.v.1996

A single right valve measuring 62.4 mm by 37 mm is provisionally associated with this genus. It is more elongate and has a stronger surface texture over the posterior area than *O. angasi* (Crosse & Fischer, 1864) (Fig. 15b). *Offadesma nakamigawai* Kuroda & Horikosi is the only other species described but also appears to be less elongate. With only a single valve at hand it is not possible to comment further and only note that this record is a considerable range extension for the genus.

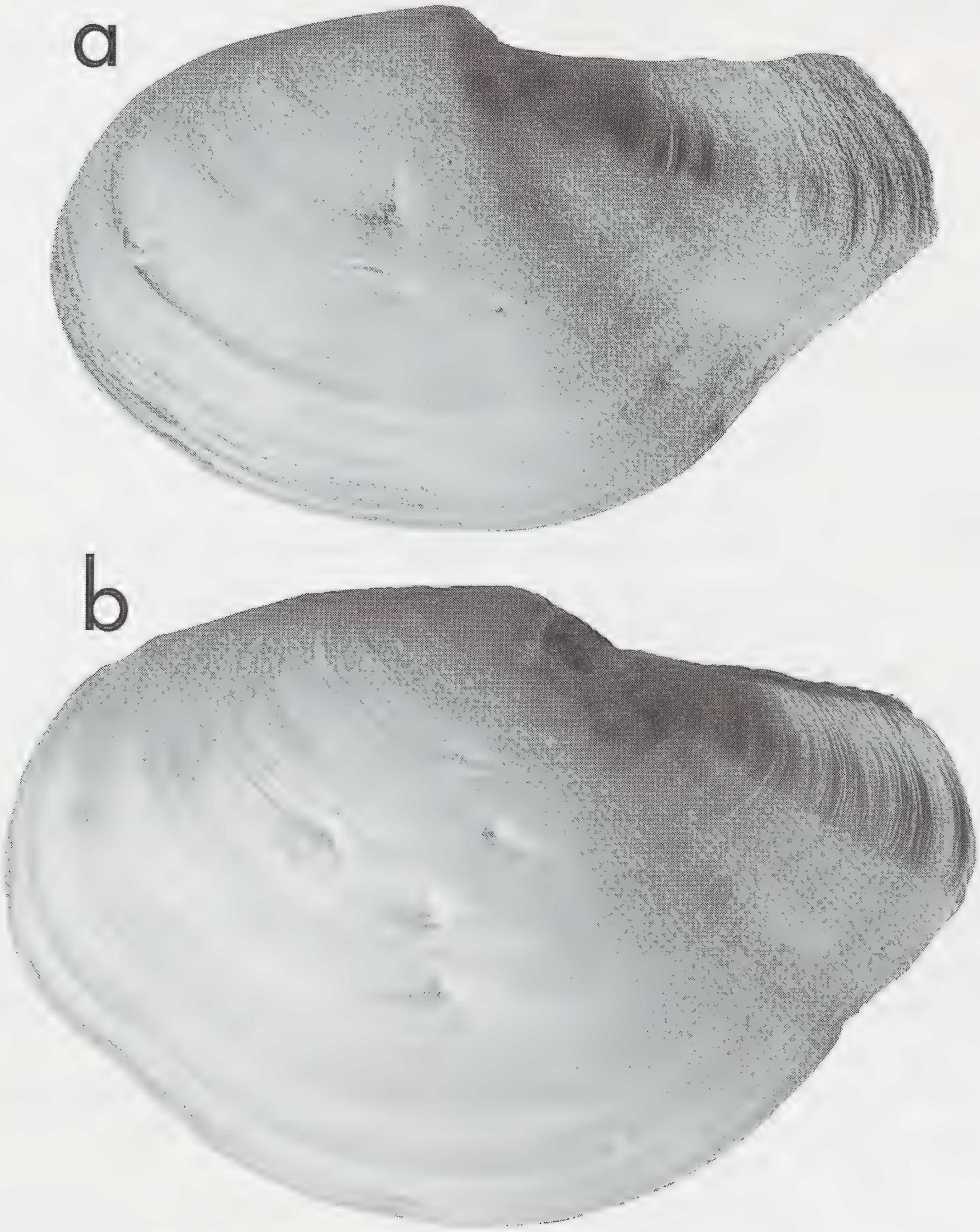


**Fig. 11 a** *Offadesma* sp., Bay of Safaga, Red Sea, 62mm. **b** *Offadesma angasi,* Tasmania, NMW.1955.158, 67mm.

## ACKNOWLEDGEMENTS

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# *LIMOPSIS TENUIS* SEGUENZA, 1876, A POORLY KNOWN MEDITERRANEAN BIVALVE (ARCOIDA, LIMOPSIDAE)

RAFAEL LA PERNA[1]

*Abstract* *The poorly known bivalve* Limopsis tenuis *Seguenza, 1876 is redescribed from the type locality, the Messina Strait. The studied material consists of valves from sandy-gravelly bottoms in 188–319 m and from Pleistocene coarse deep-sea beds near Messina.* L. tenuis *is the smallest living European limopsid (maximum size* c. *2.5 mm), although the Pleistocene valves are markedly larger (up to* c. *5 mm). It is the sole Mediterranean limopsid known from an area (the Messina Strait) far from the influence by Atlantic waters. The species is notably close in morphology and ecology to* Limopsis angusta *Jeffreys, 1879, which is also reported from the Pleistocene of Southern Italy.*

*Key words* Limopsis, *Mediterranean, Messina Strait, Quaternary.*

## INTRODUCTION

*Limopsis* Sassi, 1827 is a genus of arcoid bivalves characterised by roundish to ovate, or sub-quadrate to sub-trapezoidal, usually oblique shape, ligamental pit, radially arrayed ligament, narrow and mostly internal dorsal area. *Limopsis* is almost cosmopolitan (not occurring in the Arctic) and mainly represented by deep-sea species. It exhibits a wide range of life habits, from infaunal to epifaunal, with degrees of byssate attachments (Tevesz, 1977; Oliver & Allen, 1980; Oliver, 1981).

*L. tenuis* Seguenza, 1876 is a very poorly known species, never studied since its description. It is included in the list of the Recent Mediterranean molluscs (Sabelli *et al.*, 1990), together with *L. aurita* (Brocchi, 1814), *L. minuta* (Philippi, 1836), *L. pygmaea* (Philippi, 1836) (now *L. friedbergi* Glibert & van de Poel, 1965: Salas, 1996), all deep-water species. A shallow-water Lessepsian migrant, *L. multistriata* (Forskål, 1775), is also known (Barash & Danin, 1977).

The present work forms part of a current research on the Miocene to Recent Mediterranean species of the genus *Limopsis*. *L. tenuis* is redescribed on material from the type locality and the distribution of limopsids in the deep Mediterranean is discussed.

## SYSTEMATIC DESCRIPTION

### FAMILY LIMOPSIDAE

### Genus ***Limopsis*** Sassi, 1827

Type species *Limopsis aurita* (Brocchi, 1814)

### ***Limopsis tenuis*** Seguenza, 1876

Figs 2–26

*Limopsis tenuis* Seguenza, 1874: 80 (*nomen nudum*).
*Limopsis tenuis* Seguenza, 1876: 1.
*Limopsis tenuis* - Seguenza, 1879: 648.

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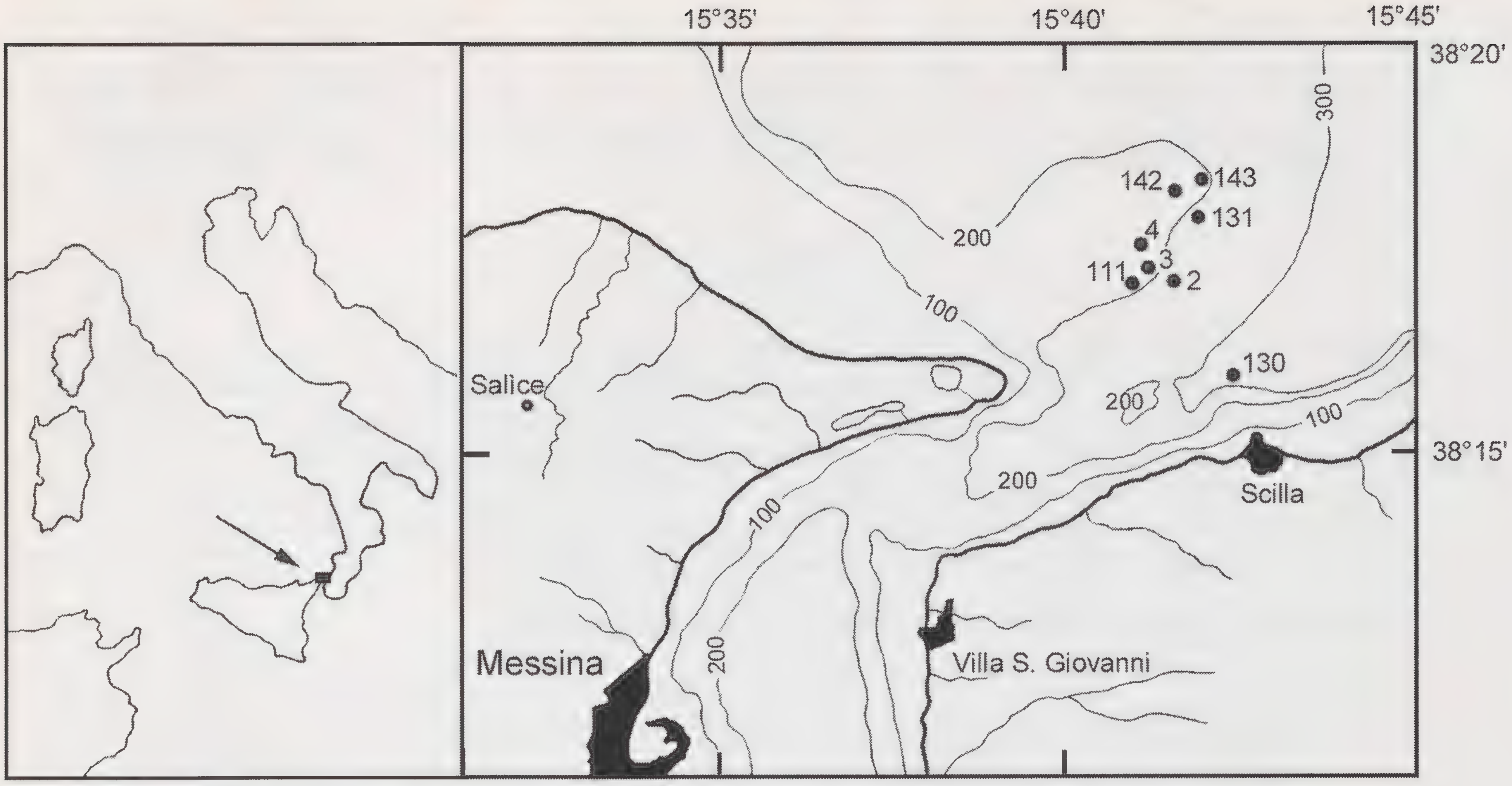


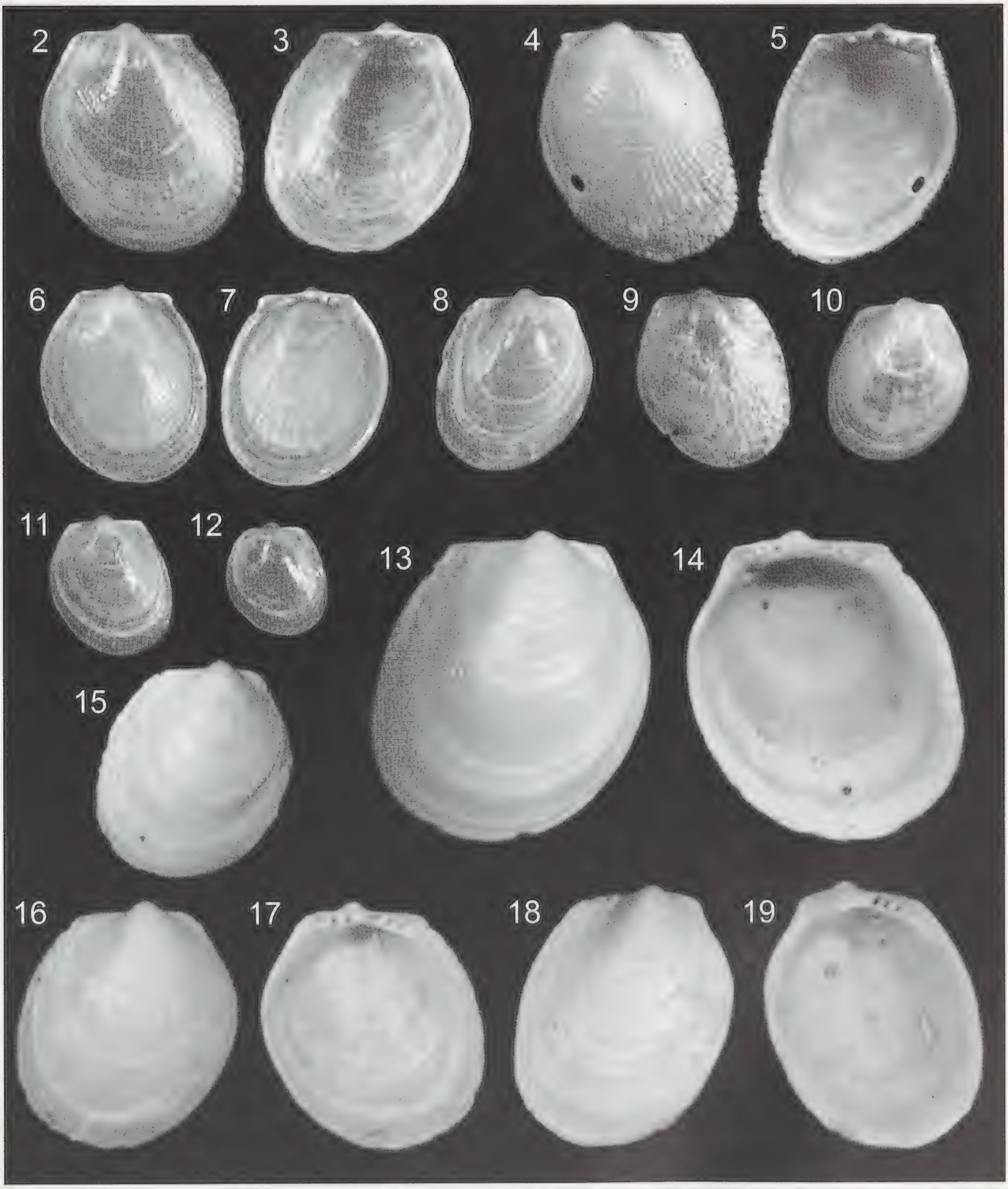
**Fig. 1** Map of stations and location of the Pleistocene outcrop (Salìce).

*Type material* Unknown.

*Material examined* "Urania" Cruise, december 1997, Messina Strait, off Scilla: 5 vs, st 2, 38°17,23′N–15°41,85′E, 216 m; 4 vs, st 3, 38°17,41′N–15°41,38′E, 198 m; 4 vs, st 4, 38°17,58′N–15°41,24′E, 190 m; 1 v, st 111, 38°17,25′N–15°41,12′E, 197 m; 1 v, st 130, 38°16,20′N–15°42,68′E, 319 m; 1 v, st 131, 38°18,00′N–15°42,26′E, 210 m; 1 v, st 142, 38°18,40′N–15°41,87′E, 188 m; 1 v, st 143, 38°18,56′N–15°42,29′E, 196 m. 5 vs, 2 fgs, Salìce, north-west of Messina, Pleistocene. University of Catania, Palaeontological Museum.

*Original diagnosis* "Similar to *L. minuta* Philippi, but very small, brittle, with finely decussate surface, margin not crenulated, without inner grooves and less teeth; epidermis as imbricated fringes along the growth lines."

*Description* Shell small, equivalve, inequilateral, obliquely ovate, moderately convex, brittle. Prodissoconch ovate, 230–240 µm large, optically smooth, brownish. Early dissoconch stage fairly well distinct, roundish, *c.* 300 µm in diameter, with fine concentric striae. Umbo small. Dorsal margin straight, comparatively long, ear-like projections at junction of dorsal and lateral margins sometimes present. Posterior margin moderately convex, curving into ventral margin. Antero-dorsal margin slightly concave due to a shallow byssal notch, becoming markedly convex a little above midpoint of shell height, then curving into ventral margin. Sculpture weak, of fine flat concentric ribs cut by radial lines more impressed posteriorly and ventrally and giving a reticulate appearance. Dorsal area narrow. Hinge plate thin. Ligamental pit triangular, deep, slightly cutting into hinge plate. Largest valve (Pleistocene) with four posterior teeth, the distal one small and indistinct, and three anterior teeth. Wide edentulous space between posterior and anterior teeth, below ligamental pit and mostly posterior to it. Inner margin flattened, narrow, smooth or with few postero-ventral elongate tubercles (Pleistocene valves). An indistinct shallow groove from umbo to postero-ventral margin, touching posterior muscle scar. Muscle scars roundish-ovate, the posterior one much larger, the anterior one somewhat impressed, below anterior end of hinge. Recent valves whitish, caramel tinged on umbo and postero-dorsal area. Periostracum yellowish, with radially arranged short bristles, forming a short fringe around postero-ventral margin.



**Figs 2–19** *Limopsis tenuis* Seguenza, 1876. **2–12** Messina Strait. **2, 3** st 2, 2.5 mm. **4, 5** st 4, 2.6 mm. **6, 7** st 4, 2.1 mm. **8** st 130, 2.0 mm. **9** st 3, 2.0 mm. **10** st 131, 1.8 mm. **11** st 2, 1.5 mm. **12** st 2, 1.2 mm. **13–19** Salìce (north-eastern Sicily), Pleistocene. **13, 14** 5.1 mm. **15** 3.6 mm. **16, 17** 4.0 mm, **18, 19** 4.3 mm. Dimensions as shell height.

Maximum size: 5.10 mm high, 4.50 mm broad, 0.62 mm tumid (Pleistocene); 2.63 mm high, 1.90 mm broad, 0.66 mm tumid (Recent).

*Habitat* *L. tenuis* was described from "coralligenous bottoms" in the Messina Strait. No depth data were given, but the molluscan fauna reported in the same work came from deep shelf rocky bottoms colonised by the stylasterid *Errina aspera* and the barnacle

*Pachylasma giganteum.* It is a rheophilic community, widespread in the Messina Strait in 80–200 m (Di Geronimo, 1987; Di Geronimo & Fredj, 1987). The present findings of fresh valves from deep sandy-gravelly current-swept bottoms (Fig. 1), widespread in the Messina Strait area (Di Geronimo, 1987; Nesteroff & Rawson, 1987), may be related to down-slope transport (fragments of *Errina* and *Pachylasma* were encountered in the examined material), but one cannot exclude that *L. tenuis* may also live on coarse-grained bottoms.

Coarse Plio-Pleistocene deep-sea beds with current structures are known from the Messina Strait area (Barrier, 1987; Di Geronimo, 1987). They are rich in skeletal remains of sessile faunas, mainly coming from nearby "White Coral" communities. The Pleistocene deposit cropping out at Salìce (Fig. 1), for which a palaeodepth of *c.* 500 m can be inferred, is a fine example of such coarse current-swept deep-sea beds.

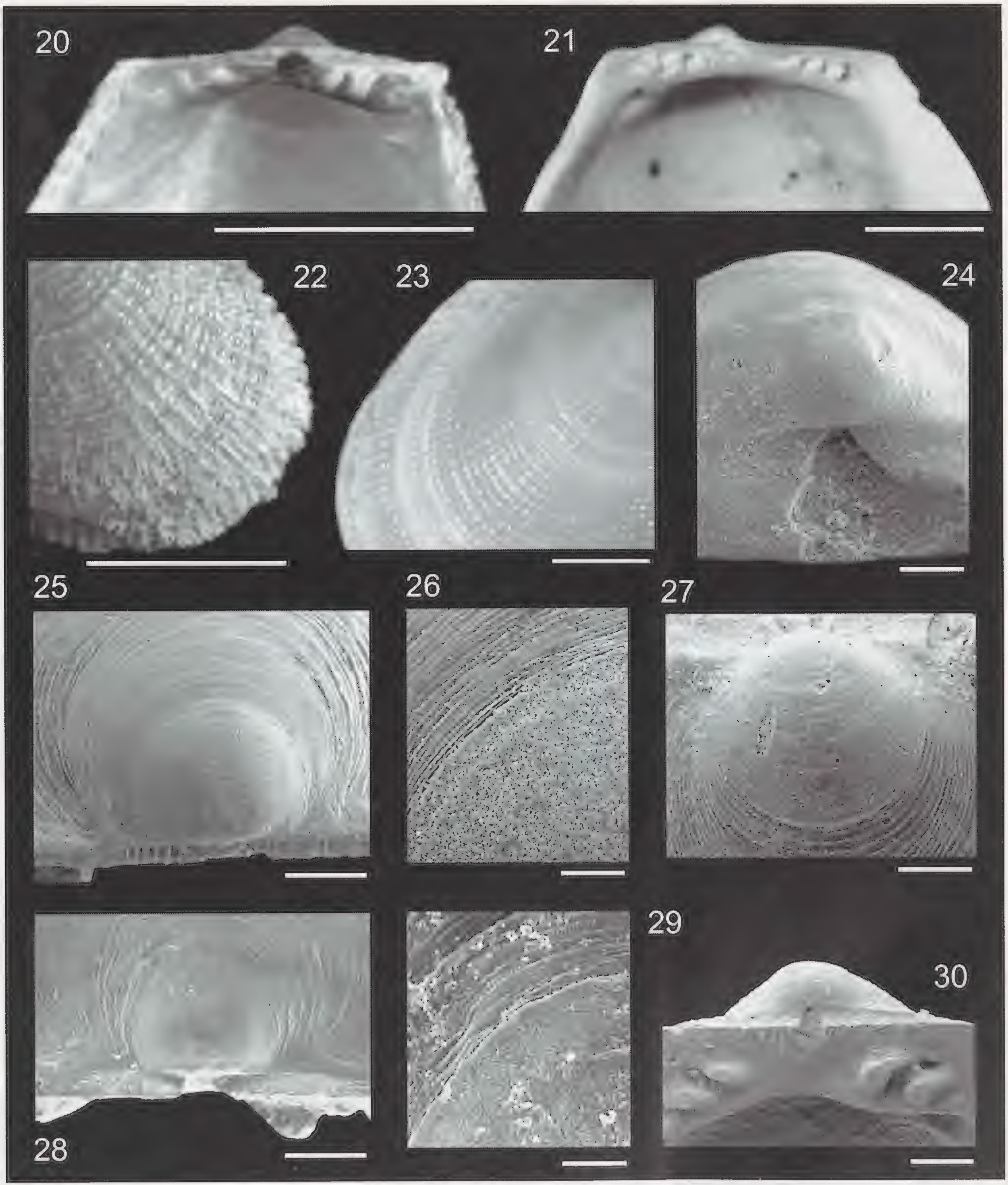
According to the studies by Oliver (1981), the shell morphology of *L. tenuis* (ovate-oblique shape, anterior reduction, advanced heteromyarian condition) points to an epibyssate life habit. Thanks to the small size, the species is most probably able to live within small cavities.

*Geographic and geologic range* Only known from the Messina Strait area, Pleistocene to Recent. The first record of *L. tenuis* was as a fossil from "Messina" (Seguenza, 1874). The species was again reported as an "Astian" fossil from the Calabrian side of the Messina Strait (Seguenza, 1879).

*Remarks* The most outstanding feature within the examined material, is the difference in size between the Pleistocene valves (maximum 5.10 mm) and the Recent ones (maximum 2.63 mm). There is no other remarkable difference to keep the Pleistocene form and the Recent one distinct. In spite of the small size, the Recent valves do not appear as juvenile stages compared to the Pleistocene ones. Rather, the former look like "miniatures" of the latter.

*L. tenuis* is rather similar in shape and sculpture to *L. angusta* Jeffreys, 1879. This species, recently revised by Salas (1996) and never recorded as a fossil, is also present in the deep-sea Pleistocene beds of Southern Italy and I take this occasion to illustrate some material (Figs 31–39). The valves of *L. angusta* are much larger, thicker and more heavily sculptured than those of *L. tenuis*. Juveniles can be also distinguished from *L. tenuis* by being thicker and more coarsely decussate. In spite of the strong size difference, *L. tenuis* and *L. angusta* appear to be more closely related to each other than to the other European limopsids. It is worth stressing the following features occurring in both species: byssal notch (notably deep in fully grown valves of *L. angusta*), decussate sculpture all over the shell outside, brown tinged umbonal area (described by Salas, 1996 on *L. angusta*), mostly smooth inner margin with posterior ribs developing with growth (see below), ovate-oblique shape appearing early in ontogeny (the juvenile stages of limopsids usually have a rounded outline; see Oliver & Allen, 1980). *L. angusta* was found by Salas (1996) mostly on rocky substrates, as also supposed for *L. tenuis*.

The largest Recent valve of *L. tenuis* (Figs 4, 5) is more elongate and thick-walled than the others, while the largest Pleistocene valve (Figs 13, 14) has three elongate tubercles on the postero-ventral inner margin. The first case may represent a fully-grown (gerontic) specimen or a shell deformation due to nestling habits. A similar elongate shape occurs in a Pleistocene valve (Figs 18, 19). To explain the second case, one may recall *L. minuta*, whose juveniles (up to *c.* 2 mm) have a smooth margin and ill-developed inner posterior ribs as elongate tubercles on the postero-ventral margin (like in the present case). With growth, the inner margin becomes crenulated and with well defined posterior ribs (Salas, 1996, La Perna, in press). In *L. angusta*, the posterior inner ribs develop when valves are 4–5 mm large, while the remaining margin is smooth. The lack or poor



**Figs 20–26** *Limopsis tenuis* Seguenza, 1876. **20** Hinge, detail of fig. 5. **21** Hinge, detail of fig. 14. **22** Sculpture and periostracum, detail of fig. 4. **23** Sculpture, detail of fig. 13. **24** Salìce, Pleistocene. Prodissoconch and ligamental pit. **25** st 2, prodissoconch and early dissoconch. **26** Detail of fig. 25. **Fig. 27** *Limopsis friedbergi* Glibert & van de Poel, 1965; Grammichele (south-eastern Sicily), Pleistocene. Prodissoconch and early dissoconch. Figs **28–30** *Limopsis minuta* (Philippi, 1836); Bovalino Superiore (southern Calabria), Pleistocene. **28** Prodissoconch. **29** Detail of fig. 28. **30** Hinge detail of a juvenile valve (1.15 mm). Scale bars = **20**, **21**, **22**, **23**, 1 mm; **24**, **25**, **27**, **28**, **30**, 100 µm; **26**, **29**, 10 µm.

development of the inner ribs in *L. tenuis* may be thus related to the small size of the species.

Another remarkable feature of *L. tenuis* is the presence of unfunctional denticles on the dorsal area (Fig. 25). Such denticles are relicts of the primary hinge developed during the earliest dissoconch stage (see below). In the Recent valves, denticles become less and less obvious with growth, but they are not apparent in the Pleistocene valves, probably also due to the slightly worn condition. Also in *L. minuta* the primary denticulation is present up to a size *c.* 2 mm (Fig. 30). This early dentition is strong evidence of the neoteneous origin of the Philobryidae (in which the primary dentition is functionally preserved in the adult stage) from the Limopsidae, as argued by Tesvez (1977).

In *L. tenuis,* the early post-larval stage is fairly well distinct from the following dissoconch, by finer close-set concentric striae (Figs 25, 26). This stage, which seems not well documented within the arcoids, can be compared with the mytilid nepioconch, which has primary denticles (Ockelmann, 1983; La Perna, 1998). A similar stage also occurs in *L. friedbergi* (Fig. 27), while it is not present in *L. minuta* (Figs 28, 29) and ill-distinct in *L. angusta*. This stage would deserve to be investigated and could represent a taxonomic tool within the genus.

*L. tenuis* has a D-shaped prodissoconch (Fig. 25), similar to that of other limopsids (Figs 27, 28), except for a little larger size. But a similarly sized prodissoconch (210–260 µm) is also present in *L. angusta.* A thin rim marks the transition to dissoconch (Fig. 26). This larval morphology may be indicative of a lecithotrophic development with a short pelagic stage (Ockelmann, 1965), as suggested by Oliver & Allen (1980) for the limopsids.

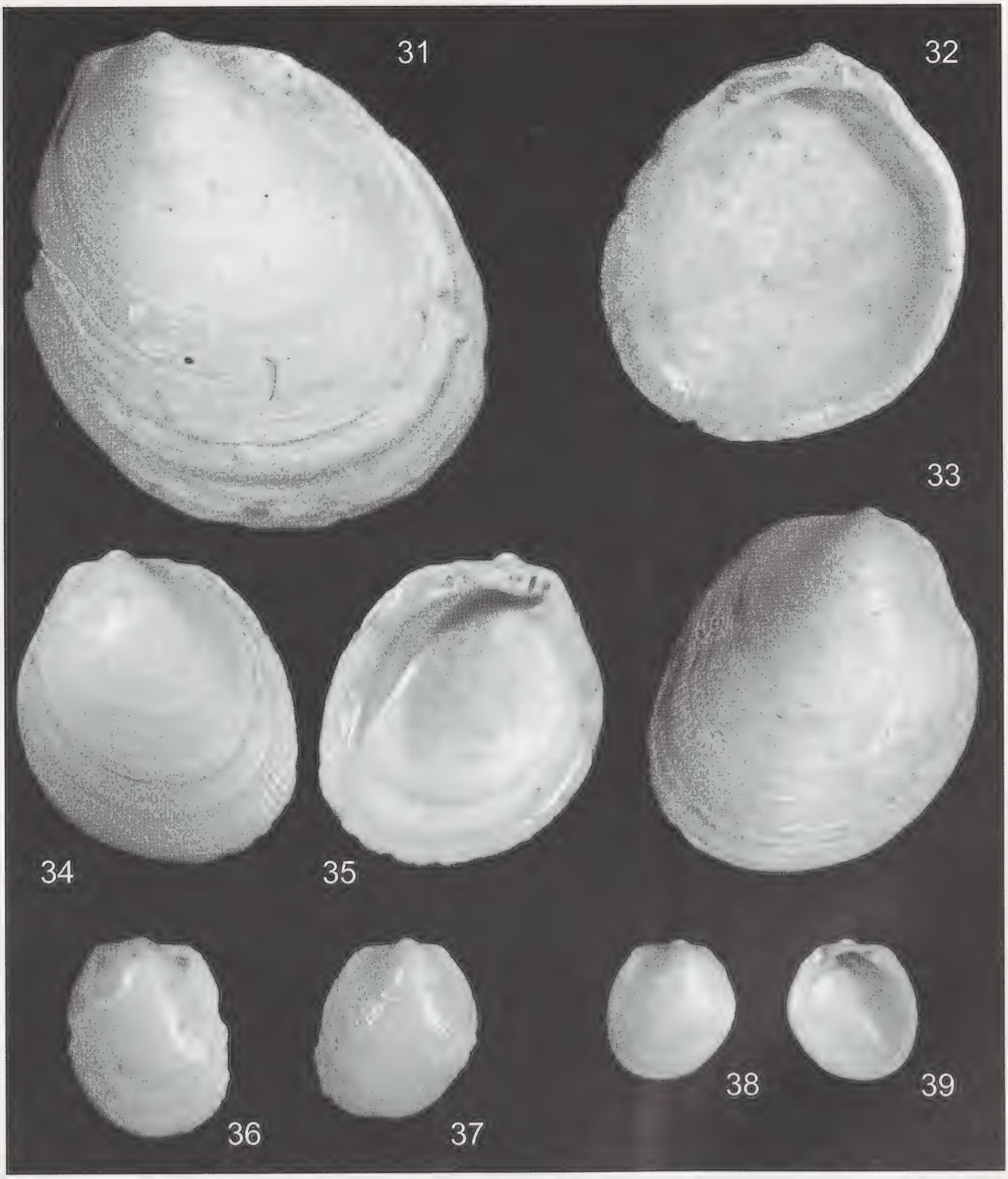
*L. tenuis* is the smallest European limopsid. The small Mediterranean bivalve described by Cecalupo (1995) as *L. sebastianoi,* is not a limopsid but probably the paedomorphic limid *Notolimea clandestina* Salas, 1994.

## Discussion

No species of *Limopsis* has been reported by recent investigations on deep-sea molluscan faunas from the Eastern Mediterranean (Janssen, 1989), the Ionian Sea (Di Geronimo & Panetta, 1973; Di Geronimo, 1974) and the Southern Tyrrhenian Sea (Di Geronimo *et al.*, in press). On the other hand, Salas (1996) reported three living species from the Alboran Sea and the Strait of Gibraltar, i.e. *L. aurita, L. minuta* and *L. angusta,* while *L. friedbergi* was found as few worn valves. *L. cristata* Jeffreys, 1876, the sole species not reported from the Alboran Sea, has a deeper range (from 540 m) in the Ibero-Moroccan Gulf (Salas, 1996), i.e. well beyond the Gibraltar sill depth (280 m). The occurrence of these species in the westernmost Mediterranean appears then to be mainly related to the influence by the Atlantic waters through Gibraltar.

*Limopsis* was instead a common component of the Pleistocene bathyal assemblages from Southern Italy, i.e. from the Central Mediterranean (Di Geronimo & La Perna, 1997; Di Geronimo *et al.*, 1997; La Perna, in press and unpubl. data). The "withdrawal" of *Limopsis* to areas influenced by the Atlantic waters can be referred to the warming of the deep Mediterranean waters in the Late Quaternary. It caused drastic changes in the deep benthos, in particular the disappearance/extinction of cold taxa of Atlantic affinity (Di Geronimo & La Perna, 1997, with references). Also the occurrence of *L. angusta* in the Central Mediterranean during the Pleistocene supports such changes in the distribution of the Mediterranean limopsids. Rare worn valves of *L. minuta* and of *L. friedbergi* from the eastern Tyrrhenian Sea (La Perna, unpubl. data) are probably of Late Glacial age.

*L. tenuis* is the sole Mediterranean limopsid known from an area not influenced by the Atlantic waters. Its depth range seems to be shallower than those of the other Atlantic-Mediterranean species, i.e. extending to the deep circalittoral. This may account for its "survival", but also the environmental conditions in the Messina Strait should be



**Figs 31–39** *Limopsis angusta* Jeffreys, 1879. **31** Salìce, Pleistocene, 9.1 mm. **32–39** Furnari (north-eastern Sicily), Pleistocene. **32** 7.1 mm **33** 6.5 mm. **34, 35** 5.1 mm. **36** 1.9 mm. **37** 1.6 mm. **38, 39** 1.4 mm. Dimensions as shell height.

considered, as they allow the development of communities of Atlantic affinity, such as the above mentioned *Errina-Pachylasma* community and *Laminaria* communities (Fredj & Giaccone, 1995). Also the reduced size may have some bearings on the adaptation of *L. tenuis* (low metabolic rate, low food demand, nestling habits). However, it should be noted that coarse current-swept deep-sea bottoms, like in the Strait of Messina, are rare. This may be the explanation why *L. tenuis* is rare.

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# A CRITICAL REVISION OF THE HISTORICAL DISTRIBUTION OF THE ENDANGERED *MARGARITIFERA AURICULARIA* (SPENGLER, 1782) (MOLLUSCA: MARGARITIFERIDAE) BASED ON MUSEUM SPECIMENS

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*Abstract* *The historical and recent distribution of* Margaritifera auricularia *is evaluated based on museum specimens. A total of 210 specimens belonging to 129 lots were studied. All recent populations of* M. auricularia *are recorded from rivers flowing to the Atlantic, Mediterranean and Adriatic. No big differences were found between the inferred distribution and the two maps published previously. Only two specimens from the River Rhine have been found, one collected in the XVIII century and the other fossil. Supposed recent specimens from this river were wrongly labelled.*

*Key words* Margaritifera auricularia, *distribution, museum collections.*

## INTRODUCTION

General interest in freshwater mussels is currently being revived because this group of molluscs harbour the highest proportion of endangered species among all the invertebrates. They are vanishing rapidly, carrying with them much undocumented genetic and biological information as many have never been fully researched.

The family Margaritiferidae includes the oldest group of nayads (Order Unionoida) and probably the most unknown and threatened. A lot of information is available on the widely distributed freshwater pearl mussel *Margaritifera margaritifera* (L.), but is scant for others in the genus. This is particularly true for the other European species, *Margaritifera auricularia,* illustrated by its recent rediscovery in 1996 (Araujo & Ramos, 1996a, b) following a gap of 63 years (Azpeitia, 1933). Altaba (1990) reported a collection of empty shells in 1990. *M. auricularia* lived in the West Palearctic although at present live specimens have only been found in the Ebro basin (Araujo & Ramos, 1996a, b, 1998a, b; Altaba, 1997; Ramos, 1998). There are only two published maps indicating its historical distribution, both including practically the same records (Preece, Burleigh, Kerney and Jarzembowski, 1983; Altaba, 1990) and both drawn without a critical review of the records based on voucher specimens. Therefore, it is difficult to link a dot on the map with a specific reference in the literature. Woodward (1996) synthesised this information in his review for the Council of Europe.

The species's former distribution on the Iberian Peninsula was studied by Araujo & Moreno (1999), who demonstrated that from 5,000 to 400 BC *M. auricularia* had a wider distribution, occurring in the Tajo, Ebro, Guadalquivir and Duero river basins.

This study attempts to establish the historical distribution of the giant freshwater pearl mussel, one of the most endangered invertebrates in the world, via a critical review of museum specimens. Assuming that species of this family are strictly specific as regards their larval hosts, the results of this research are of most interest when combined with the recorded distribution of suitable fishes.

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## MATERIAL AND METHODS

Material examined comes from collections at the following institutions:

**MNCN** Museo Nacional de Ciencias Naturales (Madrid, Spain)
**SMF** Forschungsinstitut und Naturmuseum Senckenberg (Frankfurt, Germany)
**IRSNB** Institut Royal des Sciences Naturelles de Belgique (Brussels, Belgium)
**ZMUC** Zoologisk Museum (University of Copenhagen, Denmark)
**MHNG** Museum d'Histoire Naturelle (Geneva, Switzerland)
**MNHUB** Museum für Naturkunde der Humboldt-Universität zu Berlin (Berlin, Germany)
**NMW** National Museums and Galleries of Wales (Cardiff, United Kingdom)
**MNHN** Musèum National d'Histoire Naturelle (Paris, France)
**NHM** The Natural History Museum (London, United Kingdom)
**MSNUP** Museo di Storia Naturale dell'Università di Parma (Collection P. Strobel) (Parma, Italy)
**MZUF** Museo Zoologico La Specola (Collection Paulucci) (Universitè di Firenze, Italy)
**ZMA** Instituut voor Systematiek en Populatiebiologie (Zoölogisch Museum) (Amsterdam, The Netherlands)
**RMNH** Rijksmuseum of Natural History (Leiden, The Netherlands)
**NhMW** Naturhistorisches Museum Wien (Vienna, Austria)
**USNM** United States National Museum (Washington, U.S.A.)
**OSUM** Ohio State University Museum (Columbus, Ohio, U.S.A.)
**ANSP** The Academy of Natural Sciences of Philadelphia (Philadelphia, Pennsylvania, U.S.A.)
**FMNH** The Field Museum of Natural History (Chicago, U.S.A.)

Inquiries for material were also made to the following institutions:

- North Africa: Choumovith Museum (Metlaoui, Tunisia), Zoological Park (Tunis, Tunisia), Municipal Museum (Oran, Algeria), Bedjaia Museum (Bedjaia, Algeria), Botanical Gardens (Sale, Morocco), Zoological Garden of the Chérif Scientific Institute (Rabat, Morocco).
- Portugal: Universidade de Lisboa, Museu Nacional de Historia Natural (Lisbon), Instituto Geológico e Mineiro (Museu Geológico) (Lisbon), Museu de Historia Natural (Faculdade de Ciencias do Porto) (Porto), Museu de Historia Natural da Facultade de Ciéncias e Tecnologia (Universidade de Coimbra) (Coimbra), Museu e Laboratorio Mineralogico e Geologico (Facultade de Ciencias) (Coimbra), Museu Etnografico e Arqueológico do Dr Joaquin Manso (Nazaré), Museu de Historia Natural (Museu Zoologico e Antropologico) (Lisbon), Museu de Instítuto de Zoología Dr Augusto Nobre (Porto).
- Others: Museu de Zoología (Barcelona, Spain), Royal Museum for Central Africa (Tervuren, Belgium).

A total of 210 specimens belonging to 129 lots labelled as *Margaritifera auricularia, Unio sinuatus, Pseudunio auricularia, Pseudunio auricularius, Margaritana auricularia, Margaritifera sinuata, Margaritifera marocana, Margaritifera dernaica, Margaritana marocana, Margaritana redomica,* or unnamed, were studied. Following Haas (1969), the North African forms *M. marocana, M. redomica* and *M. dernaica* are considered conspecific with *M. auricularia*. Only specimens directly examined by the authors were included. With the exceptions listed below, each specimen was measured with calipers (length, height and width) and its right valve outlined on paper. Many specimens were photographed.

Regarding the MSNUP (Italy), only the specimen drawn in Castagnolo & Nagel (1994, page 17) was considered. Specimens from the MZUF (Italy) were identified by consulting the drawings kindly sent by L. Castagnolo, and those from the Lamarck collection at the MHNG (Switzerland) by using photographs. All specimens from the RMNH (The Netherlands) and the French ones from the NhMW (Austria) were identified and measured using photocopies of the shells. Specimens from the USNM and the ANSP (USA) were identified with figures sent by D. Smith, current custodian of them.

When possible, localities of identified specimens were marked on a map, although sometimes the locality on the specimen labels was not informative (i.e. Europe).

## RESULTS

All letters sent to North African museums were returned unanswered, and no specimens of *M. auricularia* were found in the Museu de Zoología (Barcelona, Spain), the Portuguese collections or in the Royal Museum for Central Africa (Tervuren, Belgium). Several lots of shells labeled as *M. auricularia* were verified as belonging to other species: at the IRSNB (Belgium), two lots (3 specimens and 1 valve, respectively) from the Loire River (France) and one lot (1 specimen) from the Armançon River (France) were identified as *Potomida littoralis* (Lamarck), and another lot (2 specimens and 1 valve) from the Garonne River (France) as *Unio* sp; one lot (one specimen) at the NhMW (Austria) from Abbeville was also identified as *P. littoralis.* The most interesting wrongly identified material consisted of five specimens of *Unio crassus* Retzius belonging to three lots from the MHNG labeled as *Unio sinuatus* Lamarck and collected from the Rhine River. That means that the most recent record of the species in this river is an old specimen at the ZMA (The Netherlands) from a collection auctioned in 1792.

The true *M. auricularia* specimens came from almost 55 different localities of at least 11 aquatic systems in five countries. The locality of fifteen lots was unknown (Table 1). All except one specimen from the Rhine (Germany), one from the Seine (France), two from the Po basin (Italy), one from Morocco and all specimens from the River Thames, were recent specimens.

Table 1 shows detailed information on the study specimens of *M. auricularia,* and Figure 1 the inferred distribution.

## DISCUSSION

This paper is a good place to clarify the complicated story of the type locality of *M. auricularia*. The species was described by Spengler in 1793 as *Unio auricularius,* but with an obviously erroneous locality (East India). In his description Spengler (1793) mentioned one specimen with "complete umbones and artificially ground and polished until the pretty mother-of-pearl". He also indicated that his petrifications collection included fossils of this species from Berlingen in Untersee (Switzerland). On the other hand, in 1819 Lamarck described *Unio sinuatus* as a new species. It was considered to be the same species as *U. auricularius* by Mörch (Kennard, 1943) in 1870 and Westerlund (Haas, 1909). Indeed, the two names correspond to the same species, although Haas in 1909 said that Westerlund was wrong. Haas (1913) rectified the mistake, but his idea that the locality of Spengler's fossils is not the real type locality of *Unio auricularius* (Haas, 1909) is correct. That means that the type locality is unknown although several authors have cited that the type specimen is a fossil from Switzerland (Mörch, 1870 in Kennard, 1943). More recently, Turner (1987) wrote a short note indicating that there is no evidence supporting the presence of this species in Switzerland. The holotype, an artificially polished shell, is currently in the Spengler collection in the Zoologisk Museum

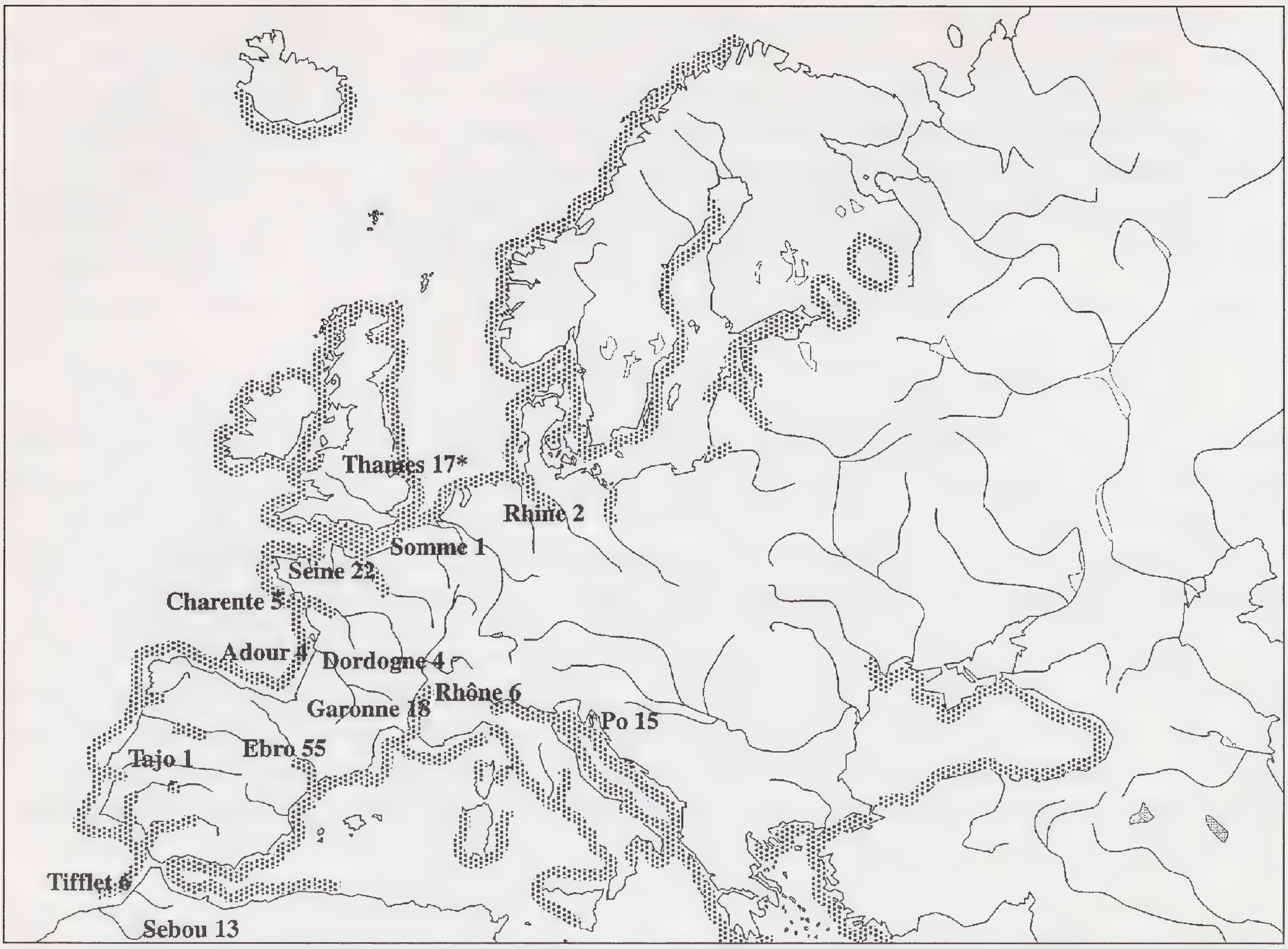

**Figure 1** Distribution of *M. auricularia* based on museum specimens; number of specimens from each river basin; and historical distribution of *Acipenser sturio* (dotted areas – modified from Lelek, 1987 and Elvira *et al.*, 1991). Asterisk indicates that all specimens are fossils.

(University of Copenhagen, Denmark) numbered BIV-315. One of the syntypes of *Unio sinuatus* in the Lamarck collection (MHNG 1086/76/1) at the Musèum d'Histoire Naturelle of Geneva is also polished.

To get a better understanding of the historical decline of *M. auricularia*, a detailed examination of museum specimens to determine their provenance is particularly interesting i.e. when they were collected and in what conditions (fresh material, shells buried for long time, subfossil or fossil). Of course, our check-map and the maps of the species's distribution published previously (Preece *et al.*, 1983; Altaba, 1990; Woodward, 1996) coincide in many points. Nevertheless, two large rivers (Guadalquivir and Loire) seem to be devoid of records for the species as regards museum specimens. There is no voucher specimen to justify the Bourguignat record for the Guadalquivir River although the species was recorded at archaeological sites in this river basin (Araujo & Moreno, 1999). Although we did not find specimens collected from the Loire River in our survey, it seems likely that the species was present there. In fact, we have noted the recent capture of live specimens in this river basin (Nienhuis, pers. com.; Bacchi and Gilbert, pers. com.) although we were not able to check their identity. On the Altaba (1990) map, there is one reference on the Tet River, a locality also recorded in Altaba (1991a, b) and based on a comment by Ortmann (1913) about two specimens from the eastern Pyrenees near Perpignan (France).

We found one specimen from the Rhine River (Germany) and several specimens from its old tributary, the Thames (England), all as fossils or subfossils. With the exception of one old and peculiar specimen (auctioned in 1792) from the Rhine at the ZMA (The

Netherlands) no recent specimens from these river basins appeared in the collections examined nor in the literature, suggesting that the species has not lived in these rivers for a long time.

Regarding British records, some are Neolithic (Kennard, 1923; Preece *et al.*, 1983) and two are much earlier (interglacial and even earlier) (Preece, 1988), indicating that the species lived in England during at least three different warm periods. The Neolithic records could indicate both that relict southern British populations remained alive during the last glaciation (very unlikely, Preece, pers. com.), or, most probably, that the Thames was successively colonized during stages of when there were no barriers to the dispersal of the species (Meijer & Preece, 1995). Following Preece *et al.* (1983): "There seems to be no biogeographical reason why *M. auricularia* should not have become re-established in the Thames during the early Holocene as soon as suitable environmental conditions returned". We may hazard that the same causes leading the species to extinction in the continental northern European rivers during the Holocene were in play on both sides of the Channel.

We did not find specimens from rivers north-east of the Rhine so the only records of *M. auricularia* in rivers flowing to the North Sea are those listed in Preece *et al.* (1983), all of them fossils. All recent populations of *M. auricularia* are recorded in its southern distribution in rivers flowing to the Atlantic, Mediterranean and Adriatic seas.

All the data suggest that the "modern" *M. auricularia* range is the result of a decline from the Northeast, as was suggested by Preece *et al.* (1983) as a clue to climatic reasons involved in the general rarification of the species. The story of the Atlantic sturgeon, a possible host fish of the *M. auricularia* glochidium (Altaba, 1990; Araujo & Ramos, 1998a, b) can probably help us to elucidate this story.

**Added in proof stage**

During publication of this manuscript, we studied two specimens of *M. auricularia* (measuring: 114.5 x 58 x 33.4 and 112 x 57.5 x 33.5) from the ZMA collected around the turn of the XX century in Mantua (Italy) and labelled as *Unio sinuatus* Lk. (= *Pseudunio auricularia* Spengler, 1793).

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## TABLE 1a

Information on *M. auricularia* study specimens. For abbreviations see Material and Methods.

| Institution | Number of specimens | Measures (mm) | Locality | Country | Main River basin | Outlet | Observations |
|---|---|---|---|---|---|---|---|
| MNCN | 1 | 48.2x25.1x15.2 | Canal Imperial, Torrero. Zaragoza. | Spain | Ebro | Mediterranean | Undetermined |
| | 2 | 76.4x39.4x22.5 | Canal Imperial, Torrero. Zaragoza. | Spain | Ebro | Mediterranean | as Margaritana auricularia Spengler |
| | 3 | 106.4x52.8x30.1 | Tajo River, Toledo | Spain | Tajo | Atlantic | as Unio auricularis Spengler |
| | 4 | 77.4x39.8x22.5 | Canal Imperial, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularis |
| | 5 | 81.4x41.3 | Canal Imperial, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularis |
| | 6 | 126x60.7x35.8 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia |
| | 7 | 126x63.7x41.15 | Garonne River | France | Garonne | Atlantic | as Unio (Margaritana) auricularius Spengler (= sinuata, Lamarck) |
| | 8 | 136.2x69x43.74 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Unio auricularis Spengler (= sinuatus, Lamarck) |
| | 9 | 145.7x71.4x40.8 | Ebro River, Cenicero, La Rioja | Spain | Ebro | Mediterranean | as Unio auricularis Spengler (= sinuatus, Lamarck) |
| | 10 | 131.8x65.3x38.6 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Unio auricularius Spengler (= sinuatus, Lamarck) |
| | 11 | 128.2x63.7x36.5 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Unio auricularius Spengler (= sinuatus, Lamarck) |
| | 12 | 143,1x64.3x41.2 | Ebro River | Spain | Ebro | Mediterranean | as Unio sinuatus Lamk |
| | 13 | 132.3x65x37.9 | Ebro River, Cenicero, La Rioja | Spain | Ebro | Mediterranean | as Unio auricularis Spengler (= sinuatus, Lamarck) |
| | 14 | 140.2x67.2x39.9 | Ebro River, Cenicero, La Rioja | Spain | Ebro | Mediterranean | as Unio auricularis Spengler (= sinuatus, Lamarck) |
| | 15 | 143.5x67.8x42.3 | Ebro River, Cenicero, La Rioja | Spain | Ebro | Mediterranean | as Unio auricularis Spengler (= sinuatus, Lamarck) |
| | 16 | 140x64.8x38.1 | Ebro River, Cenicero, La Rioja | Spain | Ebro | Mediterranean | as Unio auricularis Spengler (= sinuatus, Lamarck) |
| | 17 | 151.6x73.3x43.4 | | | | | as Unio sinuatus Lamk |
| | 18 | 131x68x40.8 | | | | | as Unio sinuatus Lamk |
| | 19 | 139.9x72.6x42.7 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Unio auricularius Spengler (= sinuatus, Lamarck) |
| | 20 | 143.7x70.9x42.7 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Unio auricularius Spengler (= sinuatus, Lamarck) |
| SMF | 1 | 94.7x51.9x26 | Ebro River, Caspe, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 2 | 124x58x34 | Ebro River, Caspe, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 3 | 134x63x40 | Chiese River, Mantua | Italy | Po | Adriatic | Old shell. As Margaritifera auricularia (SPGLR) |
| | 4 | 60x33x17.5 | Canal Imperial, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 5 | 57.9x31.4x18.2 | Canal Imperial, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 6 | 71x37.4x2 | Canal Imperial, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 7 | 98x50x27 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 8 | 94x50.5x27.2 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 9 | 101x50.8x28 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 10 | 119.8x62.8x35.5 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 11 | 113.7x60.5x32.9 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 12 | 113.3x61.4x34 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 13 | 119.9x63.6x35.3 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 14 | 96.4x50x27.6 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 15 | 122x62x34 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 16 | 115x59x33 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 17 | 116x60x36 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 18 | 83x44x25.5 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 19 | 90.8x44.3x27 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 20 | 90.4x48.3x22 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 21 | 92x49x27 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 22 | 115x60.3x34 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 23 | 116.8x65x34.7 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 24 | 118.8x62x36 | Ebro River, Gallur, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 25 | 117x52.2x33.5 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 26 | 117.7x58.4x34.3 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 27 | 120.7x53.3x34.9 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (SPGLR) |
| | 28 | 129.5x63.8x38.3 | Oglio River, Mantua | Italy | Po | Adriatic | Old shell. As Margaritifera auricularia (SPGLR) |

TABLE 1b

Information on *M. auricularia* study specimens. For abbreviations see Material and Methods.

| Institution | Number of specimens | Measures (mm) | Locality | Country | Main River basin | Outlet | Observations |
|---|---|---|---|---|---|---|---|
| IRSNB | 1 | 121.7x68.3x38 | South France | France | | | as Unio sinuatus Lam |
| | 2 | 111x58.9x4 | Garonne River | France | Garonne | Atlantic | as Unio sinuatus Lam |
| | 3 | 106x57x32 | Garonne River | France | Garonne | Atlantic | as Unio sinuatus Lam |
| | 4 | 151x81.4x43 | Saone River | France | Rhone | Mediterranean | as Unio sinuatus |
| | 5 | 158x81.4x44 | | France | | | as Unio sinuatus |
| | 6 | 87.4x5x3 | Europe | | | | as Unio sinuatus Lam and Unio margaritifera Drap |
| | 7 | 125x61x34.5 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (Spglr) |
| | 8 | 117.6x57.6x33 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (Spglr) |
| | 9 | 120x58x32.8 | Ebro River, Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (Spglr) |
| | 10 | 117x65x37.9 | Garonne River | France | Garonne | Atlantic | as Unio sinuatus Lam |
| | 11 | 116x60.8x34 | Garonne River, Agen | France | Garonne | Atlantic | as Unio sinuatus Lam |
| | 12 | 140x75x38 | Saone River | France | Rhone | Mediterranean | as Unio sinuatus |
| | 13 | 101.3x58.4 | Charente River, Taillebourg | France | Charente | Atlantic | as Unio sinuatus L |
| | 14 | 120x62.8x36 | | | | | Undetermined |
| | 15 | 131x65.5x41 | | | | | Undetermined |
| | 16 | 124x58x35.8 | Saone River | France | Rhone | Mediterranean | as Unio sinuatus |
| | 17 | 155.5x75x45 | Saone River | France | Rhone | Mediterranean | as Unio sinuatus |
| | 18 | 112.6x65.6x36 | Saone River | France | Rhone | Mediterranean | as Unio sinuatus |
| ZMUC | 1 | 128.8x70.7x35.6 | West Europe | | | | Lectotype Specimen polished, cited from East Indian as Unio auricularia |
| | 2 | 152.6x81.8x42.3 | | France | | | as Unio sinuatus Lam |
| | 3 | 126x64.5x37 | | Mexico | | | as Unio auricularius Spengler. Wrong locality |
| MHNG | 1 | 118.8x63.8x38 | Garonne River, Agen | France | Garonne | Atlantic | as Unio sinuatus Lam |
| | 2 | 105x54.3x31.3 | Chiese River, Brescia | Italy | Po | Adriatic | as Unio sinuatus Lamarck |
| | 3 | 108.2x60.8x33.8 | Canale de Cognóla, Padua | Italy | Po | Adriatic | as Unio sinuatus Lamarck |
| | 4 | 145.5x72.6x45.8 | Somme River, Abbeville | France | Somme | Atlantic | as Unio sinuatus Lamarck |
| | 5 | 111.1x64.8 | Seine River | France | Seine | Atlantic | as Unio sinuatus Lamarck. Old shell |
| | 6 | 101.5x54.5 | Seine River | France | Seine | Atlantic | as Unio sinuatus Lamarck. Old shell |
| | 7 | 96.6x51x28 | Garonne River, La Réole | France | Garonne | Atlantic | as Unio sinuatus Lamarck |
| | 8 | 110x58x34 | South France | France | | | as Unio sinuatus Lamarck |
| | 9 | 102.1x55.6x31.6 | | | | | as Unio sinuatus Lamarck |
| | 10 | 150x78.6x42.7 | Seine River, Paris | France | Seine | Atlantic | as Unio sinuatus Lamarck. Old shell |
| | 11 | 137?x67.8x41.9 | Ebro River | Spain | Ebro | Mediterranean | as Unio sinuatus Lam. Broken shell |
| | 12 | 146x80 | Europe | | | | as Unio sinuatus Lamarck. Syntype. |
| | 13 | 104x56 | Europe | | | | as Unio sinuatus Lamarck. Specimen polished. Syntype. |
| | 14 | 117x60 | Europe | | | | as Unio sinuatus Lamarck. Possible syntype. |
| | 15 | 104x57 | Europe | | | | as Unio sinuatus Lamarck. Possible syntype. |
| MNHUB | 1 | 119x60.8x33 | Castel Goffredo, Mantua | Italy | Po | Adriatic | as Unio sinuatus Lamarck |
| | 2 | 107.6x59.4x32 | Castel Goffredo, Lombardia | Italy | Po | Adriatic | as Margaritifera auricularia auricularia (Spengler) |
| | 3 | 109.7x59.3x30 | Garonne River, Agen | France | Garonne | Atlantic | as Unio sinuatus Lamarck |
| | 4 | 125.5x61x35 | | France | | | as Margaritifera (Pseudunio) auricularia (Spengler) |
| | 5 | 79x41.8x24 | Garonne River, Agen | France | Garonne | Atlantic | as Unio? sinuatus |
| | 6 | 134x66.6x35 | Adour, Padua ?? | | | | as Unio sinuatus Lam. Old shell. Two labels with two localities. |

## TABLE 1c

Information on *M. auricularia* study specimens. For abbreviations see Material and Methods.

| Institution | Number of specimens | Measures (mm) | Locality | Country | Main River basin | Outlet | Observations |
|---|---|---|---|---|---|---|---|
| NMW | 1 | 114.7x54.8x28 | Oued Derna, Taghzirt | Morocco |  | Atlantic | as Margaritana dernaica Pallary 1928. Syntype. |
|  | 2 | 74.7x37x21 | Fes | Morocco | Sebou | Atlantic | as Margaritana marocana Pallary. Syntype. |
|  | 3 | 77.6x33x23.8 | Fes | Morocco | Sebou | Atlantic | as Margaritana marocana Pallary. Syntype. |
|  | 4 | 83x40x23 | Fes | Morocco | Sebou | Atlantic | as Margaritana marocana Pallary. Syntype. |
|  | 5 | 85x40x24.9 | Fes | Morocco | Sebou | Atlantic | as Margaritana marocana Pallary. Syntype. |
|  | 6 | 50x26.5x13.6 | Fes | Morocco | Sebou | Atlantic | as Margaritana marocana Pallary. Syntype. |
|  | 7 | 115.8x63 | Ebro River, Gallur | Spain | Ebro | Mediterranean | as Margaritana auricularia Spglr. |
|  | 8 | 110x57 | Ebro River, Gallur | Spain | Ebro | Mediterranean | as Margaritana auricularia Spglr. |
|  | 9 | 150x-x41 | Adour River | France | Adour | Atlantic | as M. auricularia |
|  | 10 | 130x-x37.8 | Castel Goffredo | Italy | Po | Adriatic | as Pseudunio auricularia Sp |
|  | 11 | 138x-x40.1 | Adour River | France | Adour | Atlantic | as Pseudunio auricularia Spengler |
|  | 12 | 115x-x35.6 | Adour River | France | Adour | Atlantic | as Pseudunio auricularia Spengler |
|  | 13 | 155x-x21.2 | Thames River, Barn Elms, near London | England | Thames | Atlantic | as Pseudunio sinuatus Lk. Old shell |
|  | 14 | 109x-x31 | Thames River, Barn Elms, near London | England | Thames | Atlantic | as Pseudunio sinuatus Lk. Old shell |
|  | 15 | 138x-x17.6 | Thames River, Battersea, London | England | Thames | Atlantic | as Pseudunio auricularia Spengler. Old shell, Neolithic |
| MNHN | 1 | 118.3x58.1x40.8 | Oued Tiflet | Morocco | Tiflet | Atlantic | Undetermined |
|  | 2 | 97.3x45.7x28.2 | Oued Tiflet | Morocco | Tiflet | Atlantic | Undetermined |
|  | 3 | 132x60.8x39.8 | Oued Tiflet | Morocco | Tiflet | Atlantic | Undetermined |
|  | 4 | 78.6x39.4x24.1 | Oued Beth | Morocco | Sebou | Atlantic | Undetermined |
|  | 5 | 106.8x52.3 | Oued Beth | Morocco | Sebou | Atlantic | Undetermined. Old shell |
|  | 6 | 86.1x40.7x20 | Oued Tiflet | Morocco | Tiflet | Atlantic | as Pseudunio auricularius (Spengler) |
|  | 7 | 85.9x38.8x25 | Oued Derna | Morocco |  | Atlantic | Undetermined |
|  | 8 | 90.2x40.3x26.4 | Sebou River | Morocco | Sebou | Atlantic | as Margaritana marocana Plry |
|  | 9 | 88.1x42.5x27.3 | Sebou River | Morocco | Sebou | Atlantic | as Margaritana marocana Plry |
|  | 10 | 52.5 | Oued Tiflet | Morocco | Tiflet | Atlantic | as Margaritana redomica Plry. Broken shell |
|  | 11 | 104.3x61.3 | Charente | France | Charente | Atlantic | as U. sinuatus Lamck |
|  | 12 | 129.3x65x40.7 | Charente | France | Charente | Atlantic | as U. sinuatus Lamck |
|  | 13 | 142x72x41.7 | Charente | France | Charente | Atlantic | as U. sinuatus Lamck |
|  | 14 | 129.8x67x38.2 | Garonne River | France | Garonne | Atlantic | as U. sinuatus Lamck |
|  | 15 | 136.2x70x41.9 | Dordogne River | France | Dordogne | Atlantic | as U. sinuatus Lamck |
|  | 16 | 109.4x51.3x31.3 | Dordogne River | France | Dordogne | Atlantic | as U. sinuatus Lamck |
|  | 17 | 106x59.8x33.5 | Vesle River, Aisne | France | Seine | Atlantic | as Margaritifera auricularia (= U. sinuatus Lamk) |
|  | 18 | 105x58.3x32.6 | Vesle River, Aisne | France | Seine | Atlantic | as U. sinuatus Lamck |
|  | 19 | 14.2x72x50 | Seine River, Troyes | France | Seine | Atlantic | as U. sinuatus Lamck |
|  | 20 | 115.5x60.7x34.6 | Seine River, St. Germain | France | Seine | Atlantic | as Margaritifera auricularia Spengler (= U. sinuatus Lamk) |
|  | 21 | 124.6x69.2x36.8 | Seine River, North Rouen | France | Seine | Atlantic | as Margaritifera auricularia Spengler (= U. sinuatus Lamk) |
|  | 22 | 113.8x54x32.1 | Garonne River, Cadillac | France | Garonne | Atlantic | as Unio sinuatus |
|  | 23 | 138x64.4x43.3 | Charente River | France | Charente | Atlantic | as Unio sinuatus |
|  | 24 | 137x66.3x40.2 |  |  |  |  | as Unio sinuatus |
|  | 25 | 102.4x58x19.9 | Yonne River | France | Seine | Atlantic | as Unio sinuatus Lamck |
|  | 26 | 126.3x63x17 | Yonne River | France | Seine | Atlantic | as Unio sinuatus Lamck |
|  | 27 | 151.6x80.3 | Yonne River | France | Seine | Atlantic | as Unio sinuatus Lamck |
|  | 28 | 143.7x66x44.5 | Dronne River | France | Dordogne | Atlantic | as Unio sinuatus Lamck |
|  | 29 | 134x70.7x44.1 | Aisne River | France | Seine | Atlantic | as Unio sinuatus |
|  | 30 | 137x64.2x49 | Yonne River | France | Seine | Atlantic | as Unio sinuatus |
|  | 31 | 111x55x32 | Lot River | France | Garonne | Atlantic | as U. sinuatus |
|  | 32 | 137.3x77x40.7 | Vosges | France |  |  | as Margaritifera auricularia Spengler = U. sinuatus Lamk |
|  | 33 | 112.8x55x32.7 | Dordogne River | France | Dordogne | Atlantic | Undetermined |
|  | 34 | 123.4x61.3x38 | Arros River | France | Seine | Atlantic | as Unio sinuatus |
|  | 35 | 133.6x77.5x42.4 | Saone River, Cote d'or | France | Rhone | Mediterranean | as Unio sinuatus |
|  | 36 | 125.2x66.3x41.8 | Arros River, Htes. Pyrénées | France | Seine | Atlantic | as Margaritifera auricularia Spengler = U. sinuatus Lamk |
|  | 37 | 129.8x65x36.2 | Seine River | France | Seine | Atlantic | as Unio sinuatus |
|  | 38 | 114.7x56.3 | Adour River, Pyrénées occidentales | France | Adour | Atlantic | as Unio |
|  | 39 | 134.9x64.5x40 | Arros River | France | Seine | Atlantic | as Unio sinuatus |
|  | 40 | 150x81.3x45.6 | Saone River, St. Jean de Lone, Cote d'or | France | Rhone | Mediterranean | Undetermined |
|  | 41 | 105.8x60 | Aisne River, Braisne | France | Seine | Atlantic | as Margaritifera auricularia Spengler = U. sinuatus Lk |
|  | 42 | 119.4x66x40.3 | Aisne River, Braisne | France | Seine | Atlantic | as Margaritifera auricularia Spengler = U. sinuatus Lk |
|  | 43 | 108x60x35.8 | Aisne River, Braisne | France | Seine | Atlantic | as Margaritifera auricularia Spengler = U. sinuatus Lk |
|  | 44 | 168x79.6x48.1 | Arros River | France | Seine | Atlantic | Undetermined |
|  | 45 | 148.5x73.6x47.8 | Aisne River | France | Seine | Atlantic | as Unio |

## TABLE 1d

Information on *M. auricularia* study specimens. For abbreviations see Material and Methods.

| Institution | Number of specimens | Measures (mm) | Locality | Country | Main River basin | Outlet | Observations |
|---|---|---|---|---|---|---|---|
| NHM | 1 | Fragments | Wiesbaden Region, bank of Rhine River | Germany | Rhine | Atlantic | as Pseudunio (margaritifera) auricularia (Spengler). Old Shell, year 6.100 BC |
| | 2 | 132x71.7 | Barn Elms, Mortlake | England | Thames | Atlantic | Undetermined. Old shell |
| | 3 | 140.7x72.3 | Barn Elms, Mortlake | England | Thames | Atlantic | Undetermined. Old shell |
| | 4 | 147.6x75 | Barn Elms, Mortlake | England | Thames | Atlantic | Undetermined. Old shell |
| | 5 | 123.2x72.4 | Barn Elms, Mortlake | England | Thames | Atlantic | Undetermined. Old shell |
| | 6 | 151.8x74 | Barn Elms, Mortlake | England | Thames | Atlantic | Undetermined. Old shell |
| | 7 | 137.5x73.9 | Barn Elms, Mortlake | England | Thames | Atlantic | as Pseudunio auricularius, Spengler. Old shell, lowest Holocene |
| | 8 | 158x75 | Barn Elms, Mortlake | England | Thames | Atlantic | as Pseudunio auricularius, Spengler. Old shell, lowest Holocene |
| | 9 | 147x71.4 | Barn Elms, Mortlake | England | Thames | Atlantic | as Pseudunio auricularius, Spengler. Old shell, lowest Holocene |
| | 10 | 141.3x77 | Thames River | England | Thames | Atlantic | as Margaritifera auricularia (Spengler). Old shell, Holocene, Neolithic |
| | 11 | 153.7x83.8 | Thames River | England | Thames | Atlantic | as Unio auricularia Spengler. Old shell, Holocene |
| | 12 | 143.5x78.4 | Thames River, Mortlake | England | Thames | Atlantic | as Unio auricularia Spengler. Old shell, Holocene |
| | 13 | 160.9x72.5x45 | Thames River, Mortlake | England | Thames | Atlantic | as Unio auricularia Spengler. Old shell, Holocene |
| | 14 | 135x72.6 | Thames River, Mortlake | England | Thames | Atlantic | as Margaritifera auricularia (Spengler). Old shell, Holocene |
| | 15 | 150x81.3 | Thames River, Mortlake | England | Thames | Atlantic | as Margaritifera auricularia (Spengler). Old shell, Holocene |
| | 16 | 82x43.7 | Oued Fez | Morocco | Sebou | Atlantic | as Margaritana marocana Pallary. Syntype |
| | 17 | 83.8x42 | Oued Fez | Morocco | Sebou | Atlantic | as Margaritana marocana Pallary. Syntype |
| MSNUP | 1 | 148.2x67.9 | Acquanegra, Mantovano | Italy | Po | Adriatic | as Unio sinuatus |
| MZUF | 1 | 138.6x70.3x46 | Mantovano | Italy | Po | Adriatic | as Unio sinuatus Lamarck |
| | 2 | 122.3x60.7x38 | Castel Goffredo, Brescia | Italy | Po | Adriatic | as Unio sinuatus Lamarck |
| | 3 | 141.6x68.5x44 | Chiese River, Mantova | Italy | Po | Adriatic | as Unio sinuatus Lamarck |
| | 4 | 136x68x39 | Canal N Cognola, Padova | Italy | Po | Adriatic | as Unio sinuatus Lamarck |
| ZMA | 1 | x64x39 | Gironde | France | Garonne | Atlantic | as Margaritifera auricularia Spengl. and Pseudunio auricularia (Spengler, 1793) |
| | 2 | 156x74x47.5 | Gironde | France | Garonne | Atlantic | as Margaritifera auricularia Spengl. and Pseudunio auricularia (Spengler, 1793) |
| | 3 | 122.7x64x39.3 | France | France | | | as Margaritifera auricularia Spengl. (=sinuata Lam) and Pseudunio auricularia (Spengler, 1793) |
| | 4 | 110x55.5x32 | Rhine | | Rhine | Atlantic | as Margaritifera auricularia Spengl. (=sinuata Lam) and Pseudunio auricularia (Spengler, 1793). Auctioned in 1792 |
| | 5 | 121x63x30.5 | Agen | France | Garonne | Atlantic | as Margaritifera margaritifera (L), Unio sinuatus (Lamk) and M. auricularia |
| | 6 | 105x51x30 | Oued Beth, Sidi Slimane, Middle Atlas | Morocco | Sebou | Atlantic | as Margaritifera auricularia. Collected alive in 1991 |
| | 7 | 106x48.3x30 | Oued Beth, Sidi Slimane, Middle Atlas | Morocco | Sebou | Atlantic | as Margaritifera auricularia. Collected alive in 1991 |
| RMNH | 1 | 131x64 | Ebro by Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (Spengler) (=Unio sinuatus Lamarck) |
| | 2 | 121x61 | Ebro by Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia (Spengler) (=Unio sinuatus Lamarck) |
| NhMW | 1 | 140.7x64x38 | Canali del fiume Chiese, near Asola, Mantua | Italy | Po | Adriatic | as Unio sinuatus Lam. Old shell |
| | 2 | 174x79 | South France | France | | | as Unio sinuatus Lmk. |
| | 3 | 124.5x63 | South France | France | | | as Unio sinuatus Lmk. |
| USNM | 1 | 74.4x39.6 | Garonne River, near Bourdeaux | France | Garonne | Atlantic | as Margaritifera auricularia (Spengler) |
| OSUM | 1 | 114.5x59x37 | Garonne River, Gironde | France | Garonne | Atlantic | as Margaritifera auricularia Spengler |
| ANSP | 1 | 80x42 | Agen | France | Garonne | Atlantic | as U. sinuatus Lam |
| | 2 | 128.6x65.4 | Ebro River, Bitem, Tarragona | Spain | Ebro | Mediterranean | as Margaritifera auricularia (Spengler) |
| | 3 | 101x53 | Lot et Garonne | France | Garonne | Atlantic | as U. sinuatus Lam |
| | 4 | 130.2x60 | Mantua | Italy | Po | Adriatic | as U. sinuatus Lam |
| FMNH | 1 | 134x64x38.8 | Roggia Ciusella, Acquanegra-sul-Chiese, Mantua | Italy | Po | Adriatic | as Margaritifera auricularia Spglr. Old shell |
| | 2 | 103x52.3x29.6 | Ebro River near Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia Spengler |
| | 3 | 118x59x31.6 | Ebro River near Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia Spengler |
| | 4 | 112.3x57.5x30.7 | Ebro River near Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia Spengler |
| | 5 | 113.4x50.3x30.9 | Ebro River near Sástago, Zaragoza | Spain | Ebro | Mediterranean | as Margaritifera auricularia Spengler |

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# TWO *PLATYLA* SPECIES FROM SARDINIA (GASTROPODA: PROSOBRANCHIA: ACICULIDAE)

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*Abstract* *Recent field work led to the discovery of two* Platyla *species in Sardinia where no aciculids had hitherto been reported. One of these species,* P. sardoa *n. sp., is similar to the fossil* P. klemmi *from the Lower Pliocene of Celleneuve near Montpellier (France) and the Upper Pliocene of the Rhine Valley (Germany) and to the recent* P. lusitanica *from southern Portugal. It has a reduced range in the central-eastern part of the island, but it is locally frequent. The other species,* Platyla *sp., recalls* P. gracilis, P. cryptomena *and* P. microspira. *It is easily distinguished from the first two species, but its relationship with the last is difficult to define. Although it has a wider range than the other species, it is locally rather scarce.*

*Key words* *Aciculidae,* Platyla sardoa *n. sp.* Platyla *sp., Sardinia, Italy.*

## INTRODUCTION

The aciculids (Aciculidae) are a family of small and cryptic land operculate prosobranch gastropods living in the litter and soil, endemic to the western Palaearctic.

The taxonomy of the family is exclusively based on shell characters. Anatomical studies have only been performed in a few species and have not provided any character useful for taxonomy because of the simplification and homogeneity of the genitalia and other internal organs (Creek, 1954; Jackiewicz, 1967; Bodon & Boato, 1987; Boeters *et al.*, 1989; Bodon, 1994). The shell characters of taxonomic interest are shell shape and size, presence / absence of sculpture (radial grooves and ribs; spiral grooves), presence / absence and structure of the external peristomal rib and the sinulus. The taxonomy is rather difficult at species level because splitting is very high *(Acicula* includes 27 species, two with two subspecies, *Menkia* 4 species, *Platyla* 31 species, one with two subspecies, and *Renea* 11 species, two with two subspecies; Boeters *et al.*, 1989; Gittenberger, 1991; Bodon, 1994; Stworzewicz & Stoltys, 1996) and most of the species are distinguished by very weak characters. Consequently, although the aciculids have recently been the subject of a complete monograph by Boeters *et al.* (1989), their taxonomy still has some problems, especially with regard to species delimitation and relationship. However, until further distinguishing characters are found, it will be difficult to propose a different approach to acicululid taxonomy that is not affected by a degree of subjectivity.

Three species are known from Sicily: *Acicula benoiti* (Bourguignat, 1864), *Platyla polita* (Hartmann, 1840) (present with the nominotypical subspecies *P. polita polita*) and *P. subdiaphana* (Bivona, 1839) (Boeters *et al.*, 1989; Bodon *et al.*, 1995), but no species are known from any other major Mediterranean island such as the Balearic Is., Sardinia, Corsica, Crete and Cyprus (Boeters *et al.*, 1989). This is strange because the aciculids are a very ancient group dating back to the Lower Tertiary and have a distribution that includes the lands bordering the central-western Mediterranean. It may be due to their cryptic habit and the absence of accurate research. In fact, recent field work led to the discovery of two *Platyla* species in Sardinia where none – neither fossil nor recent – had ever previously been recorded (Esu, 1978, 1984, 1986; Esu & Kotsakis, 1983; Giusti & Castagnolo, 1983; Boeters *et al.*, 1989; Esu & Girotti, 1991; Bodon *et al.*, 1995). One of these species is widespread and the other has a reduced range in the central-eastern part of the island.

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*Platyla* includes 31 species of fossil and recent aciculids having smooth shells (apart from a few growth lines) without axial / radial or spiral sculpture (grooves or ribs), widespread in Europe and Turkey (Boeters *et al.*, 1989: Fig. 18b). These species can be roughly distinguished into three groups on the basis of absence / presence and structure of the external peristomal rib. The first group, including *P. jankowskiana* (Jackiewicz, 1979), *P. klemmi* (Schlickum & Strauch, 1972), *P. lusitanica* (Holyoak & Seddon, 1985), *P. minutissima* Boeters, Gittenberger & Subai, 1989, *P. perpusilla* (Reinhardt, 1880), *P. stussineri* (Boettger, 1884) and *P. turcica* Boeters, Gittenberger & Subai, 1989, is characterised by the absence of an external peristomal rib. The second group, including *P. callosa* (Boettger, 1880), *P. curtii* (Wagner, 1912), *P. dupuyi* (Paladilhe, 1868), *P. eocaena* (Oppenheim, 1895), *P. orthostoma* (Jackiewicz, 1979), *P. peloponnesica* Boeters, Gittenberger & Subai, 1989, *P. procax* Boeters, Gittenberger & Subai, 1989, *P. similis* (Reinhardt, 1880) and *P. wilhelmi* (Wagner, 1910), is characterised by an external peristomal rib without abrupt posterior delimitation. Finally, the third group, including *P. alta* (Clessin, 1911), *P. banatica* (Rossmässler, 1842), *P. callostoma* (Clessin, 1911), *P. cryptomena* (De Folin & Bérillon, 1877), *P. elisabethae* (Pintér & Szigethy, 1973), *P. falkneri* Boeters, Gittenberger & Subai, 1989, *P. foliniana* (Nevill, 1879), *P. gracilis* (Clessin, 1887), *P. maasseni* Boeters, Gittenberger & Subai, 1989, *P. microspira* (Pini, 1884), *P. pezzolii* Boeters, Gittenberger & Subai, 1989, *P. pinteri* (Subai, 1976), *P. polita polita* (Hartmann, 1840), *P. polita regina* (Subai, 1977), *P. subdiaphana* (Bivona, 1839) and *P. subfusca* (Flach, 1889), is characterised by an external peristomal rib which is marked posteriorly by a simple line (*P. cryptomena* and *P. microspira)* or a step in relief (all the others).

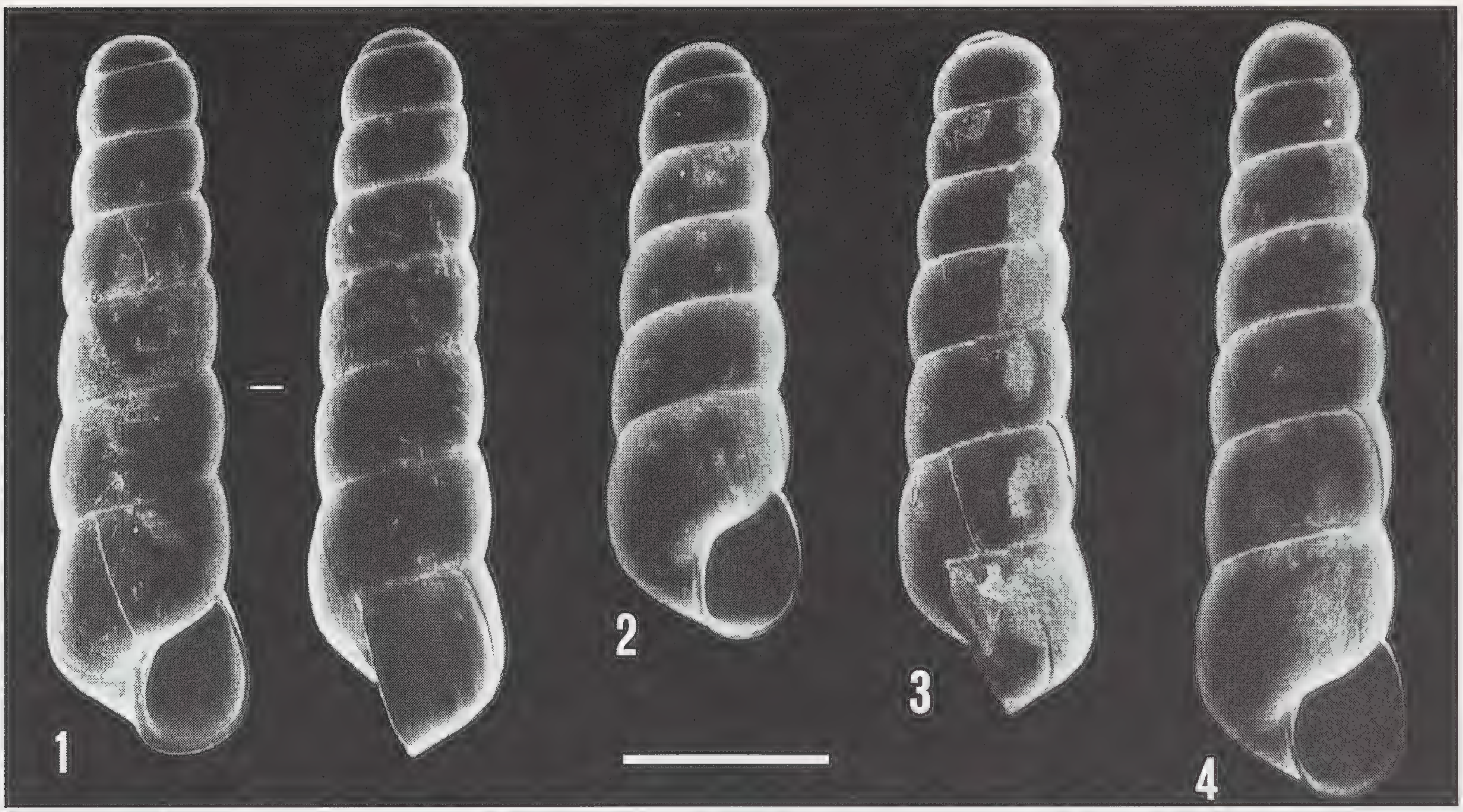
One of the two Sardinian species belongs to the first group and is described here as a new species. The other belongs to the third group and is similar to *P. microspira.*

## MATERIALS AND METHODS

Shells were collected by sieving litter and soil. They were mounted on copper blocks with conductive carbon cement, sputter-coated with graphite and gold and photographed using a Philips 515 SEM. All measurements (shell height, shell diameter, aperture height and aperture diameter) were measured using a micrometer lens on the light microscope (Wild M5A).

The material examined is listed as follows: locality; municipality, province and region names in parenthesis; UTM reference; collector(s) and date; number of specimens (sp) or shells (sh) and collection where deposited in parentheses. Locality names and UTM references are according to the official 1:25,000 scale map of Italy.

Most type and other material examined is in the Museo Zoologico "La Specola", Sezione del Museo di Storia Naturale dell'Università di Firenze, Via Romana 17, Firenze, Italy (MZUF). Other type material and the rest of the material examined is in the malacological collection of the Nationaal Natuurhistorisch Museum, Leiden, The Netherlands (NNM) and in the private collections of M. Bodon (Via delle Eriche 100/8, Genova, Italy, MBC), S. Cianfanelli (P.le Porta Romana 13, Firenze, SCC), D. Esu (Dipartimento di Scienze della Terra, Università La Sapienza, Piazzale delle Scienze, Roma, Italy, DEC), F. Giusti (Dipartimento di Biologia Evolutiva dell'Università, Via Mattioli 4, Siena, Italy, FGC), M. Sosso (Via Paglia 65/3, Genova, Italy, MSC), and E. Talenti (P.zza Parri 4, Incisa, Firenze, ETC).



**Figs 1–4** Shells of *Platyla sardoa* n. sp. from Badde Ghiramonte (Siniscola, Nuoro, Sardinia), 32TNK5892, S. Cianfanelli & E. Talenti leg. 27.10.1995 (MZUF no. 11573). Scale bar = 1 mm.

## ***Platyla sardoa*** n. sp.

*Holotype* 1 shell, S. Cianfanelli & E. Talenti leg. 27.10.1995, kept in malacological collection of the Museo Zoologico de "La Specola" (Firenze, Italy) (MZUF no. 11572).

*Paratypes* 136 shells, as follows:
- Type locality, M. Bodon leg. 24.3.1989 (28 sh MBC; 4 sh NNM no. 59395), S. Cianfanelli & E. Talenti leg. 27.10.1995 (61 sh MZUF no. 11573, 10 sh FGC).
- Cave Cane Gortoe, Siniscola (Siniscola, Nuoro), 32T NK 5892, M. Bodon, F. Giusti & G. Manganelli leg. 22.11.1986 (3 sh MBC).
- Near fountain Sa Mela, Monte Albo between Siniscola and Lula (Siniscola, Nuoro), 32T NK 5491, S. Cianfanelli & E. Talenti leg. 27.10.1995 (7 sh MZUF no. 11576).
- Near fountain Mariane Jana, Monte Albo between Siniscola and Lula (Lodè, Nuoro), 32T NK 5187, S. Cianfanelli & E. Talenti leg. 21.5.1993 (2 sh SCC 6241/1098).
- La Poltrona, Cala Gonone (Dorgali, Nuoro), 32T NK 5359, A. Angori leg. 5.4.1997 (1 sh ETC).
- Valle Fuili, Cala Gonone (Dorgali, Nuoro), 32T NK 5256, M. Sosso leg. 5.11.1986 (3 sh MSC), M. Bodon, F. Giusti & G. Manganelli leg. 22.11.1986 (1 sh MBC); M. Bodon leg. 25.3.1989 (6 sh MBC); M. Sosso leg. 9.1986 (2 sh MSC), S. Cianfanelli & E. Talenti leg. 21.5.1993 (1 sh SCC 6893/1320), S. Cianfanelli & E. Talenti leg. 28.10.1995 (4 sh MZUF 11574).
- Near Cave Su Palu, Codula di Luna (Urzulei, Nuoro), 32T NK 4848, S. Cianfanelli & E. Talenti leg. 29.10.1995 (7 sh MZUF no. 11575).

*Type locality* Badde Ghiramonte, Siniscola (Siniscola, Nuoro), 32T NK 5892.

*Description* Shell (Figs 1–9) very small, fragile, elongate cylindro-conical, with obtuse apex, colourless, glassy and transparent when fresh. Spire consisting of 6–7½ slightly convex and slowly growing whorls. Last whorl ⅖ or less of shell height, its last portion slightly ascending. Sutures shallow, with weak subsutural line. External surface of protoconch smooth with no particular microsculpture (Figs 5–7). External surface of teleoconch smooth (Fig. 8), with thin growth lines; growth lines often more marked on last whorls, rather regularly spaced (at distance of about ½ whorl), closer to one another near peristome. Aperture squarish-pyriform, slightly oblique, small, about ⅕ of shell height. Peristome simple, interrupted, slightly thickened, reflexed only at lower and columellar margin; upper and lower vertices of peristome joined by very thin parietal callosity; upper part of external margin, seen laterally, slightly sinuous and not re-entrant; columellar callosity slightly developed. No external callous rib behind peristome (Fig. 9). Umbilicus closed.

Operculum and anatomical characters unknown.

*Measurements* Shell height: 2.68–3.80 mm; shell diameter: 0.87–1.10 mm; aperture height: 0.65–0.76 mm; aperture width: 0.47–0.62 mm.

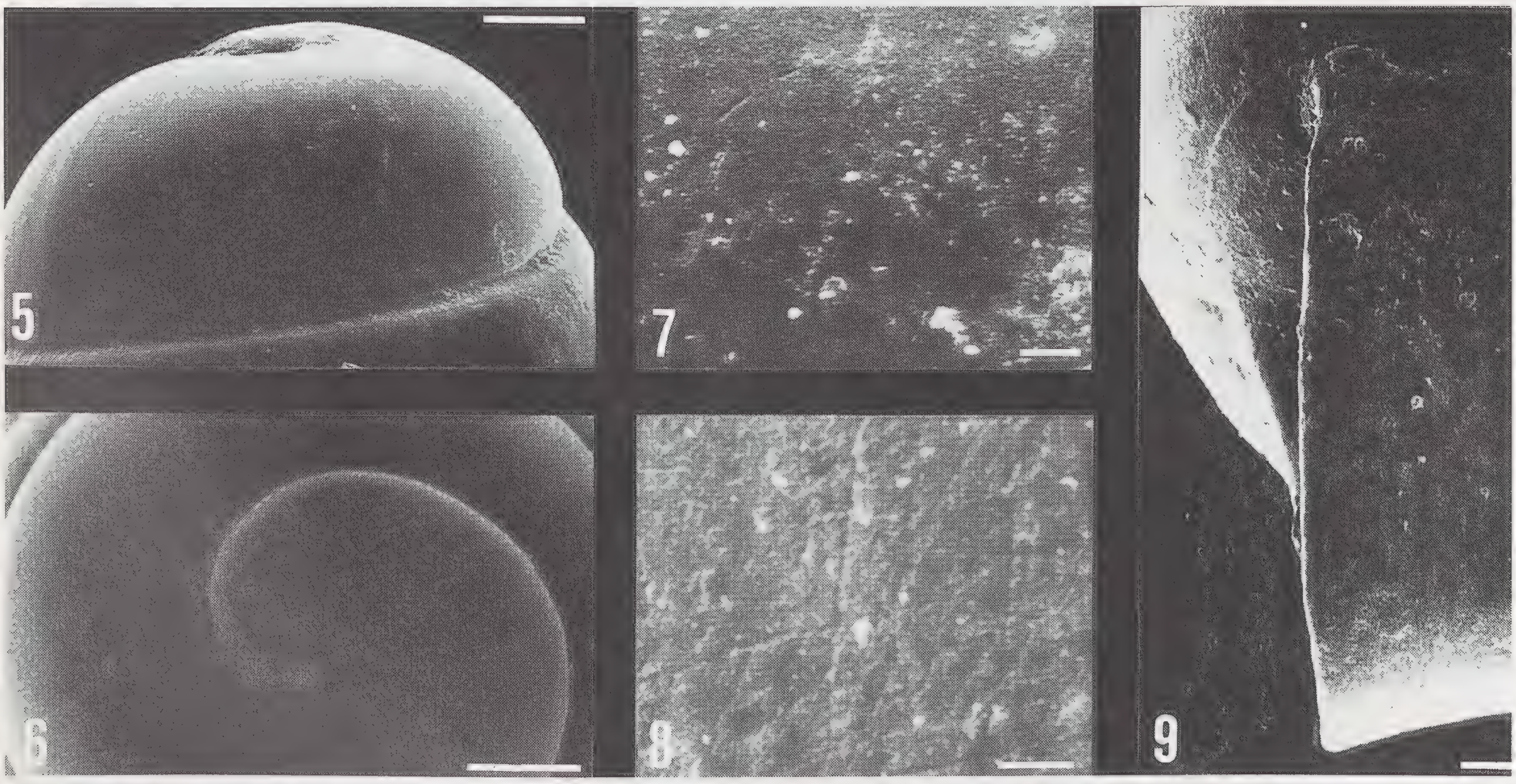
*Derivation of name* *"sardoa"* from the island of Sardinia.

*Habitat* The exact habitat (litter or soil) of *P. sardoa* n. sp. is unknown because live specimens have never been found. The species has been collected from sea level to 800 m asl. and is locally abundant.

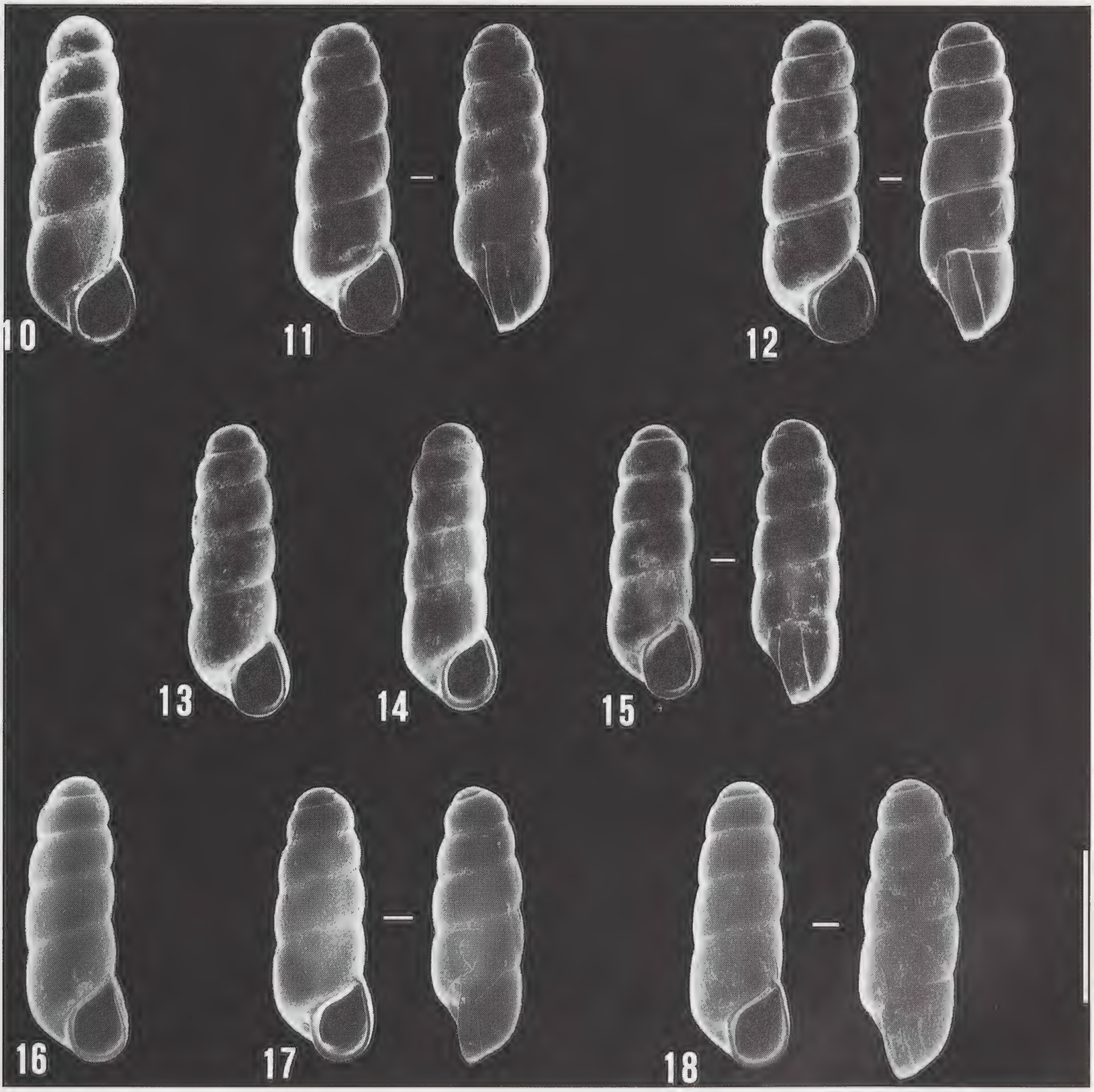
*Geographical range* *P. sardoa* n. sp. has a reduced distribution, limited to the calcareous massifs of central-eastern Sardinia (Fig. 30).

*Comparisons and remarks* *P. sardoa* n. sp. lacks an external peristomal rib, like *P. jankowskiana, P. klemmi, P. lusitanica, P. minutissima, P. perpusilla, P. stussineri and P. turcica.*

The new species is easily distinguished from *P. minutissima, P. perpusilla, P. stussineri* and *P. turcica* by virtue of its larger size and cylindro-conical elongated shell (smaller size, shell height never more than 2.0 mm and cylindrical shell in *P. minutissima, P. perpusilla, P. stussineri* and *P. turcica;* Boeters *et al.*, 1989: Figs 131–133, 155–156, 159). It is also easily distinguished from *P. jankowskiana,* which is larger in size than the four



**Figs 5–9** Details of shell of *Platyla sardoa* n. sp. from Badde Ghiramonte (Siniscola, Nuoro, Sardinia), 32TNK5892, S. Cianfanelli & E. Talenti leg. 27.10.1995 (MZUF no. 11573). **5–6** Protoconch, microsculpure of **7** protoconch and **8** teleoconch and **9** external peristomal margin. Scale bar = 100 µm (**5–6, 9**), 10 µm (**7–8**).



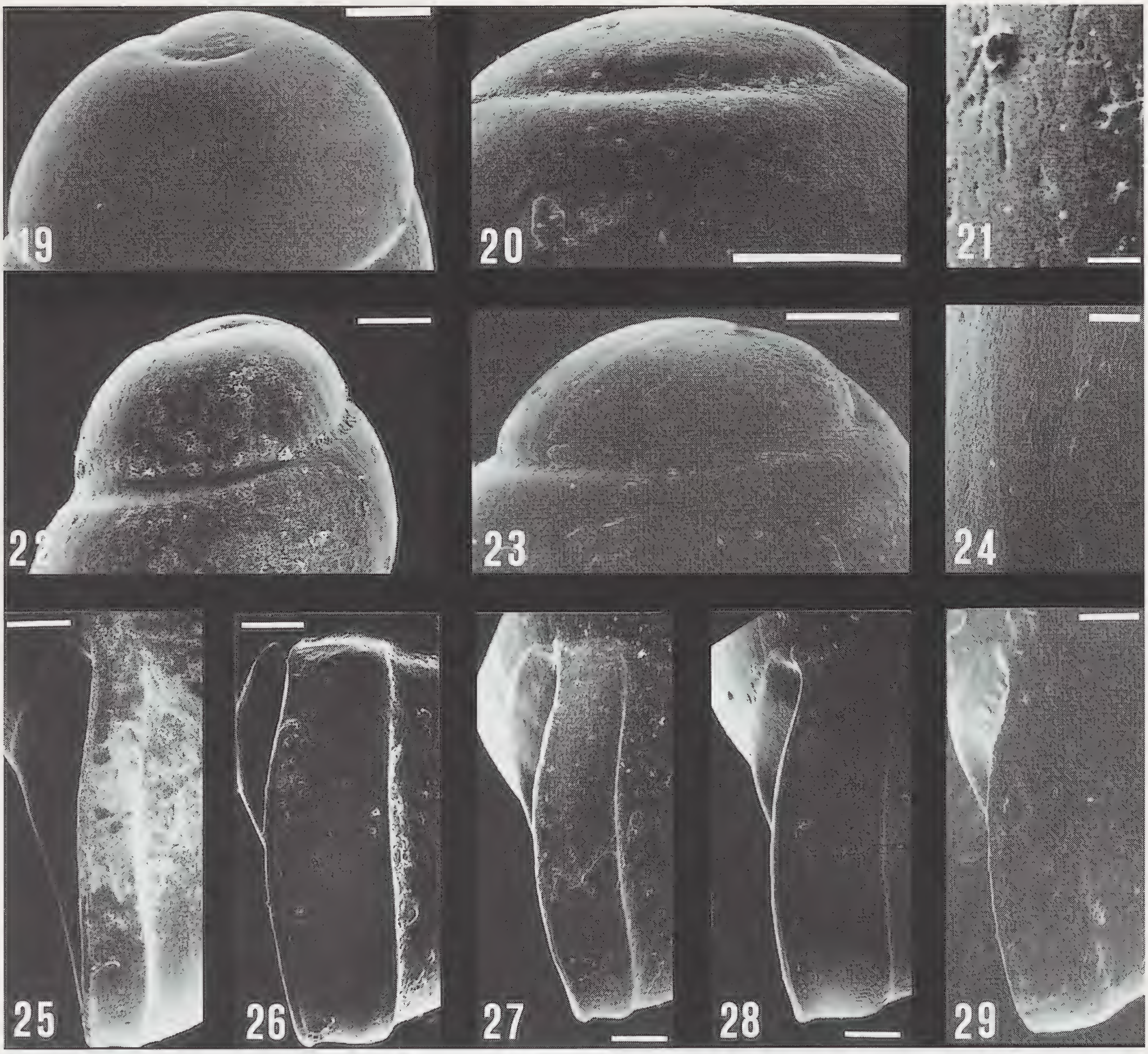
**Figs 10–18** Shells of:

*Platyla* sp. **10–11** Badde Ghiramonte (Siniscola, Nuoro, Sardinia), 32TNK5892, S. Cianfanelli & E. Talenti leg. 27.10.1995 (MZUF no. 11571) **12** Park of the Marquis of Laconi, Laconi (Laconi, Nuoro, Sardinia), 32SNK0411, M. Sosso leg. 2.4.1986 (MZUF no. 11571).

*Platyla* cf. *microspira* (Pini, 1884) **13–15** Monte Circeo, Le Crocette (S. Felice Circeo, Latina, Latium), 33TUF3966, M. Bodon leg. 5.4.1996 (MZUF no. 11583).

*Platyla microspira* (Pini, 1884) **16** debris of Fiume Magra near la Chiesaccia, Lusuolo (Mulazzo-Villafranca in Lunigiana, Massa Carrara, Tuscany), 32TNQ760009, M. Bodon leg. 26.10.1994 (MZUF 15917) **17** Avolasio, Val Taleggio (Vedeseta, Bergamo, Lombardy), 32TNR48, S. Cianfanelli leg. 24.3.96 (MZUF no. 15916) **18** from debris of Lago di Annone near Galbiate (Galbiate, Como, Lombardy), 32TNR2873, M. Bodon leg. 7.10.1989 (MZUF no. 16022). Scale bar = 1 mm.

species discussed above, but always smaller (shell height: 2.4–2.6 mm; Boeters *et al.*, 1989: 125) than the new species, by virtue of its elongate cylindro-conical shell and more oblique (in lateral view) external margin of peristome (cylindrical shell and external margin of peristome seen in lateral view slightly oblique to almost parallel to shell axis



**Figs 19–29** Details of shell of:

*Platyla* sp. **19–21**, **25** Badde Ghiramonte (Siniscola, Nuoro, Sardinia), 32TNK5892, S. Cianfanelli & E. Talenti leg. 27.10.1995 (MZUF no. 11571) and **26** Park of the Marquis of Laconi, Laconi (Laconi, Nuoro, Sardinia), 32SNK0411, M. Sosso leg. 26.9.86 (MZUF no. 11592).

*Platyla* cf. *microspira* (Pini, 1884) **22**, **27–28** Monte Circeo, Le Crocette (S. Felice Circeo, Latina, Latium), 33TUF3966, M. Bodon leg. 5.4.1996 (MZUF no. 11583).

*Platyla microspira* (Pini, 1884) **23–24** debris of Fiume Magra near la Chiesaccia, Lusuolo (Mulazzo-Villafranca in Lunigiana, Massa Carrara, Tuscany), 32TNQ760009, M. Bodon leg. 26.10.1994 (MZUF 15917) and **29** debris of Lago di Annone near Galbiate (Galbiate, Como, Lombardy), 32TNR2873, M. Bodon leg. 7.10.1989 (MZUF no. 16022). Protoconch (**19-20**, **22-23**), microsculpure of teleoconch (**21**, **24**) and external peristomal rib (**25-29**).

Scale bar = 100 µm (**19-20, 22-23, 25-29**), 10 µm (**21, 24**).

in *P. jankowskiana;* Boeters *et al.*, 1989: Figs 123–124).

Distinction with respect to *P. klemmi* and *P. lusitanica* is more problematical. These two species share with *P. sardoa* an elongate cylindro-conical shell and oblique (in lateral view) external margin of peristome (forming angle of about 20° with the shell axis).

The fossil *P. klemmi,* from the Lower Pliocene of Celleneuve near Montpellier (France) and the Upper Pliocene of the Rhine Valley (Tagebau Frechen der Rheinischen Braunkohlenwerke A.G., 3 Sohle, Tiefschnitt; Tagebau Fortuna bei Bergheim, grüner

Ton w. Peringshofsprung, 2 Sohle; Germany) mainly differs by virtue of its smaller size (shell height 1.55–2.30 mm; shell diameter 0.55–0.70 mm; Schlickum & Strauch, 1972: 77, Figs 1–2; Boeters *et al.*, 1989: 126–127, Figs 125–126).

The recent *P. lusitanica*, from southern Portugal, is similar in size (shell height 2.6–3.5 mm; shell diameter 0.9–1.0 mm; Boeters *et al.*, 1989: 128) to the new species, but the last whorls of the teleoconch are light brown (colourless in *P. sardoa),* the shape is less slender (shape more elongated in *P. sardoa),* the apical whorls are slightly more convex and the last whorl is slightly shorter (Holyoak & Seddon, 1985: 63–64, Pl. 8 A–C; Boeters *et al.*, 1989: 127–128, Figs 127a–b).

Although these species are very similar we propose the Sardinian one as a new species due to the fact that there are differences without an overlap in more than one character and in consideration of the large distributional gap between them. On the basis of the characters mentioned earlier (in particular the sculpture and the "juvenile"-like shape) it is probable that *P. lusitanica* and *P. sardoa* are sister taxa.

The affinity of *P. sardoa* with the western European *P. lusitanica* and *P. klemmi* is very interesting. These species might belong to a group with western European distribution, partially fragmented by drift of the Sardocorsican microplate (see Giusti & Manganelli, 1984, for details and references) (the other species of the group, *P. jankowskiana, P. minutissima, P. perpusilla, P. stussineri* and *P. turcica,* are diffused in the central-eastern and southern Europe and Turkey). This is only a hypothesis. The characters shared by these species (absence of external peristomal rib and slightly oblique in lateral view external margin of peristome) present in juvenile shells of all aciculids may be neotenic and acquired by parallel evolution.

*Status and conservation* *P. sardoa* n. sp. has a limited distribution, but it does not seem to be under any particular threat. Consequently it can be regarded as a not globally threatened species.

## ***Platyla*** **sp.**

*Description* Shell (Figs 10–12, 19–21, 25–26) very small, rather fragile, cylindrical elongate, with obtuse apex, yellowish – brown in colour, glassy and transparent when fresh. Spire consisting of 5–6 slightly convex, slowly growing whorls. Last whorl about ⅖ of shell height, its last portion ascending. Sutures shallow, with weak subsutural line. External surface of protoconch smooth with no particular microsculpture (Figs 19–20). External surface of teleoconch smooth (Fig. 21) with thin growth lines, some more marked and rather regularly spaced (at distance of about ½ whorl from each other). Aperture pyriform, slightly oblique, small, about ¼ of shell height. Peristome simple, rather thickened, slightly reflexed at lower and columellar margin, its upper vertices joined by rather thick parietal callosity (peristome apparently uninterrupted); upper part of external margin, seen laterally, slightly sinuous and not re-entrant; columellar callosity slightly developed. External callous rib behind peristome evident, moderately raised, variably wide (0.11–0.20 mm), sharply delimited posteriorly by simple line (Figs 25–26). Umbilicus closed.

Operculum and anatomical characters unknown.

*Measurements* (Table 1) Shell height: 1.95–2.40 mm; shell diameter: 0.67–0.78 mm; aperture height: 0.55–0.62 mm; aperture width: 0.39–0.47 mm.

*Material examined*

- Debris of Rio Su Catala between Alghero and Ittiri (Uri, Sassari), 32T MK 5296, S. Cianfanelli & E. Talenti leg. 19.5.1993 (1 sh SCC 6834/1319), S. Cianfanelli & E. Talenti

TABLE 1

Dimensions of shell (in mm) in populations of *P. microspira* from northern Italy (Lombardy, Liguria) and Tuscany, *P.* cf. *microspira* from Latium and *Platyla* sp. from Sardinia. H shell height, D shell diameter, h aperture height, d aperture diameter, N number of shells; mean ± standard deviation and range (in parenthesis).

| **Species** | **Locality** | **H** | **D** | **h** | **d** | **N** |
|---|---|---|---|---|---|---|
| *P. microspira* | Debris of Lago di Annone near Galbiate (Galbiate, Como) | 1.97<br>(1.94 - 2.01) | 0.70<br>(0.69 - 0.71) | 0.57<br>(0.56 - 0.58) | 0.42<br>(0.41 - 0.43) | 3 |
| | Monte Croce, Vo' di Moncodeno (Esino Lario, Como), | 2.00<br>(2.00 - 2.00) | 0.74<br>(0.72 - 0.76) | 0.61<br>(0.60 - 0.62) | 0.43<br>(0.42 - 0.45) | 2 |
| | Debris of Torrente Enna, Taleggio (Taleggio, Bergamo) | 1.96 ± 0.09<br>(1.82-2.12) | 0.71 ± 0.02<br>(0.67 - 0.75) | 0.58 ± 0.02<br>(0.55 - 0.62) | 0.45 ± 0.02<br>(0.40 - 0.47) | 19 |
| | Orrido di Bracca (Zogno, Bergamo) | 1.97 | 0.66 | 0.56 | 0.41 | 1 |
| | Spring of Canale di Redarca (Lerici, La Spezia) | 1.92 | 0.70 | 0.57 | 0.41 | 1 |
| | Debris of Canal Grande near the spring Fada (Ameglia, La Spezia) | 1.90 ± 0.12<br>(1.70 - 2.03) | 0.68 ± 0.02<br>(0.64 - 0.71) | 0.55 ± 0.02<br>(0.52 - 0.57) | 0.40 ± 0.01<br>(0.40 - 0.41) | 8 |
| | Debris of Fiume Magra, Villafranca in Lunigiana (Pontremoli, Massa Carrara) | 1.80 ± 0.07<br>(1.68 - 1.92) | 0.67 ± 0.02<br>(0.62 - 0.68) | 0.53 ± 0.02<br>(0.50 - 0.56) | 0.39 ± 0.01<br>(0.37 - 0.40) | 8 |
| | Debris of Fiume Magra near la Chiesaccia (Mulazzo-Villafranca in L., Massa Carrara) | 1.90 ± 0.04<br>(1.84 - 1.94) | 0.68 ± 0.04<br>(0.62 - 0.72) | 0.57 ± 0.01<br>(0.56 - 0.58) | 0.39 ± 0.01<br>(0.37 - 0.40) | 5 |
| | Debris of Fiume Magra upstream of Ponte Quarlieri, Terrarossa (Tresana, Massa Carrara) | 1.95 | - | - | - | 1 |
| | Debris of Fiume Magra, Isola, Albiano (Aulla, Massa Carrara), | 1.89<br>(1.84 - 1.95) | 0.69<br>(0.68 - 0.71) | 0.55<br>(0.55 - 0.56) | 0.39<br>(0.39 - 0.40) | 2 |
| *P.* cf. *microspira* | Monte Circeo, Le Crocette (S. Felice Circeo, Latina) | 1.95 ± 0.08<br>(1.76 - 2.07) | 0.67 ± 0.01<br>(0.64 - 0.70) | 0.53 ± 0.03<br>(0.49 - 0.60) | 0.39 ± 0.02<br>(0.36 - 0.42) | 19 |
| | Monte Circeo, Quarto Freddo (S. Felice Circeo, Latina) | 1.90<br>(1.83 - 1.98) | 0.67<br>(0.66 - 0.68) | 0.56<br>(0.55 - 0.57) | 0.39<br>(0.39 - 0.40) | 2 |
| | Valle Viola, Val Marina (Monte S. Biagio, Latina) | 1.72<br>(1.68 - 1.76) | 0.62<br>(0.60 - 0.64) | 0.49<br>(0.47 - 0.50) | 0.37<br>(0.36 - 0.38) | 3 |
| *Platyla* sp. | Debris of Rio Su Catala between Alghero and Ittiri (Uri, Sassari) | 2.09<br>(2.05 - 2.12) | 0.71<br>(0.70 - 0.72) | 0.58<br>(0.56 - 0.60) | 0.40<br>(0.40 - 0.41) | 2 |
| | Badde Ghiramonte, Siniscola (Siniscola, Nuoro) | 2.14 ± 0.14<br>(1.95 - 2.40) | 0.72 ± 0.02<br>(0.67 - 0.76) | 0.59 ± 0.02<br>(0.55 - 0.62) | 0.43 ± 0.02<br>(0.39 - 0.46) | 30 |
| | Cave Cane Gortoe, Siniscola (Siniscola, Nuoro) | 2.07 | 0.72 | 0.57 | 0.41 | 1 |
| | Park of the Marquis of Laconi (Laconi, Nuoro) | 2.20 ± 0.09<br>(2.08 - 2.30) | 0.74 ± 0.03<br>(0.70 - 0.78) | 0.59 ± 0.02<br>(0.57 - 0.61) | 0.45 ± 0.02<br>(0.42 - 0.47) | 8 |
| | Cortoghiana, Iglesias (Carbonia, Cagliari) | 2.12 | 0.75 | - | - | 1 |

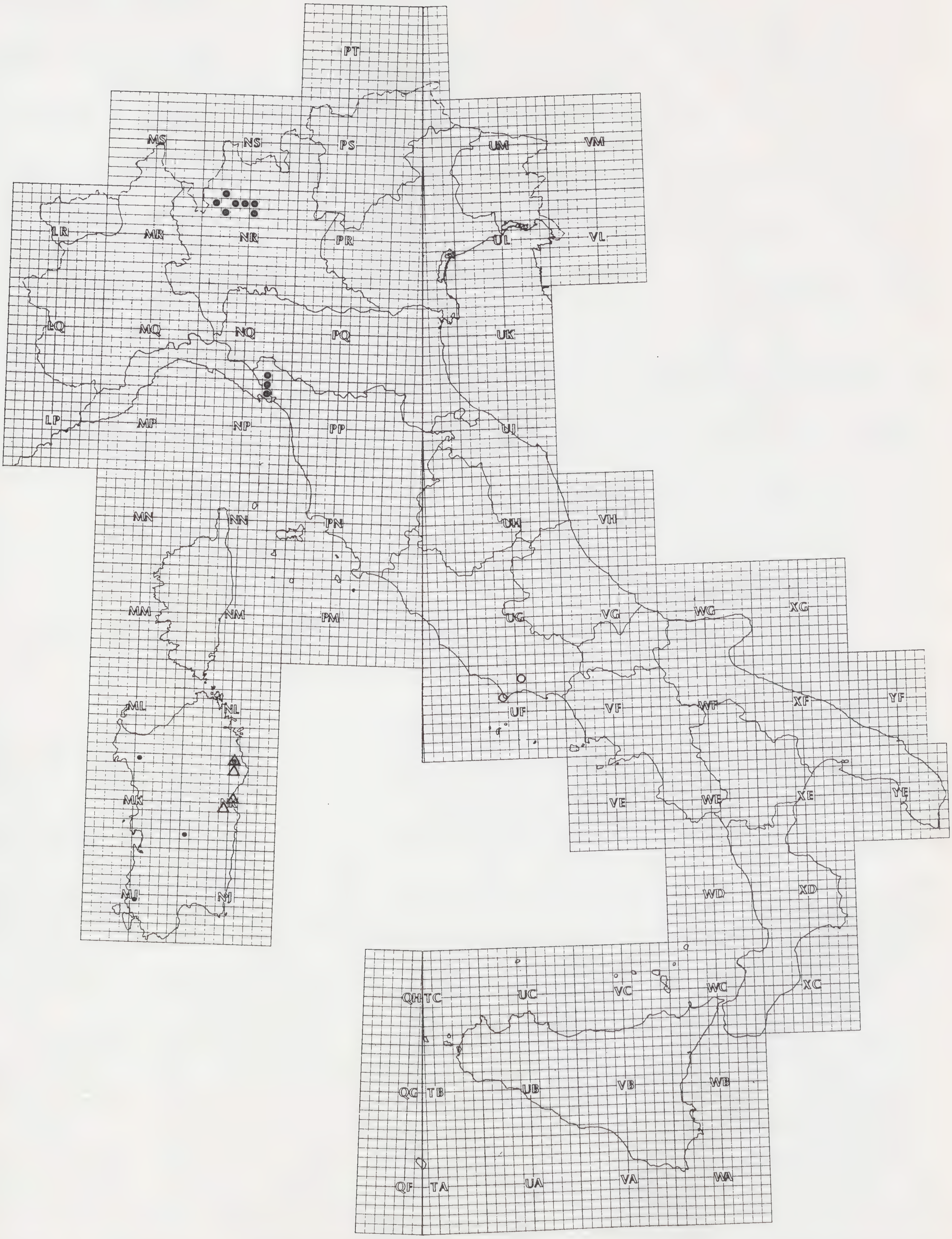


**Fig. 30** Distribution of *Platyla sardoa* n. sp from Sardinia (triangles), *Platyla* sp. from Sardinia (small full dots), *P.* cf. *microspira* from Latium (circles) and *P. microspira* from northern Italy and Tuscany (large full dots) on UTM map of Italy, with on 10 X 10 kilometre squares.

leg 1.11.1995 (2 sh MZUF no. 11570).

- Near Cantoniera Seredda, Uri (Ittiri, Sassari), 32T MK 5895, S. Cianfanelli & E. Talenti leg. 19.5.1993 (1 sh SCC 6894/1319).
- Badde Ghiramonte, Siniscola (Siniscola, Nuoro), 32T NK 5892, M. Bodon leg. 24.3.1989 (14 sh MBC), S. Cianfanelli & E. Talenti leg. 27.10.1995 (24 sh MZUF no. 11571).
- Cave Cane Gortoe, Siniscola (Siniscola, Nuoro), 32T NK 5892, M. Bodon, F. Giusti & G. Manganelli leg. 22.11.1986 (4 sh MBC, 1 shell NNM 57264).
- Park of the marquis of Laconi (Laconi, Nuoro), 32S NK 0411, M. Sosso leg. 2.4.1986 (2 MSC, 1 sh MZUF 11592), M. Sosso 26.9.86 (1 sh MSC).
- Cortoghiana, Iglesias (Carbonia, Cagliari), 32S MJ 54, D. Esu leg. 1984 (1 sh DEC).

*Habitat* *Platyla* sp. lives in litter, on calcareous substrata at 50–550 m of altitude and is locally rather scarce.

*Geographical range* The species is known from scattered localities in Sardinia. It is probably under-recorded and more widespread. (Fig. 30).

*Comparison and remarks* Some modest shell differences characterise the populations of

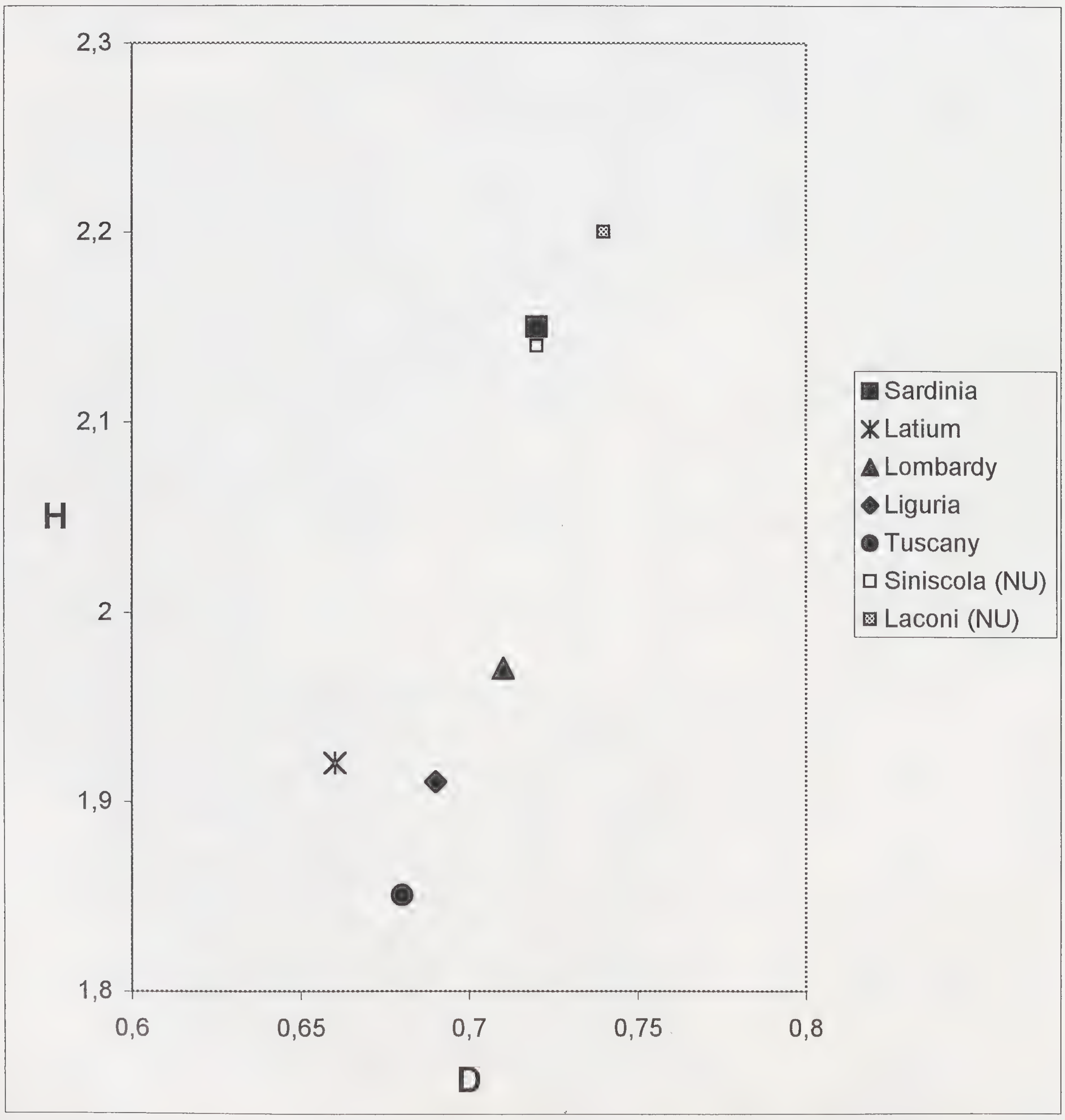


**Fig. 31** Distribution of mean shell height (H) and diameter (D) (in mm) of populations of *Platyla* sp. from Sardinia (and of the populations from Siniscola and Laconi, separately), of *P.* cf. *microspira* from Latium and of *P. microspira* from northern Italy (Lombardy, Liguria) and Tuscany. Populations as in Table 1.

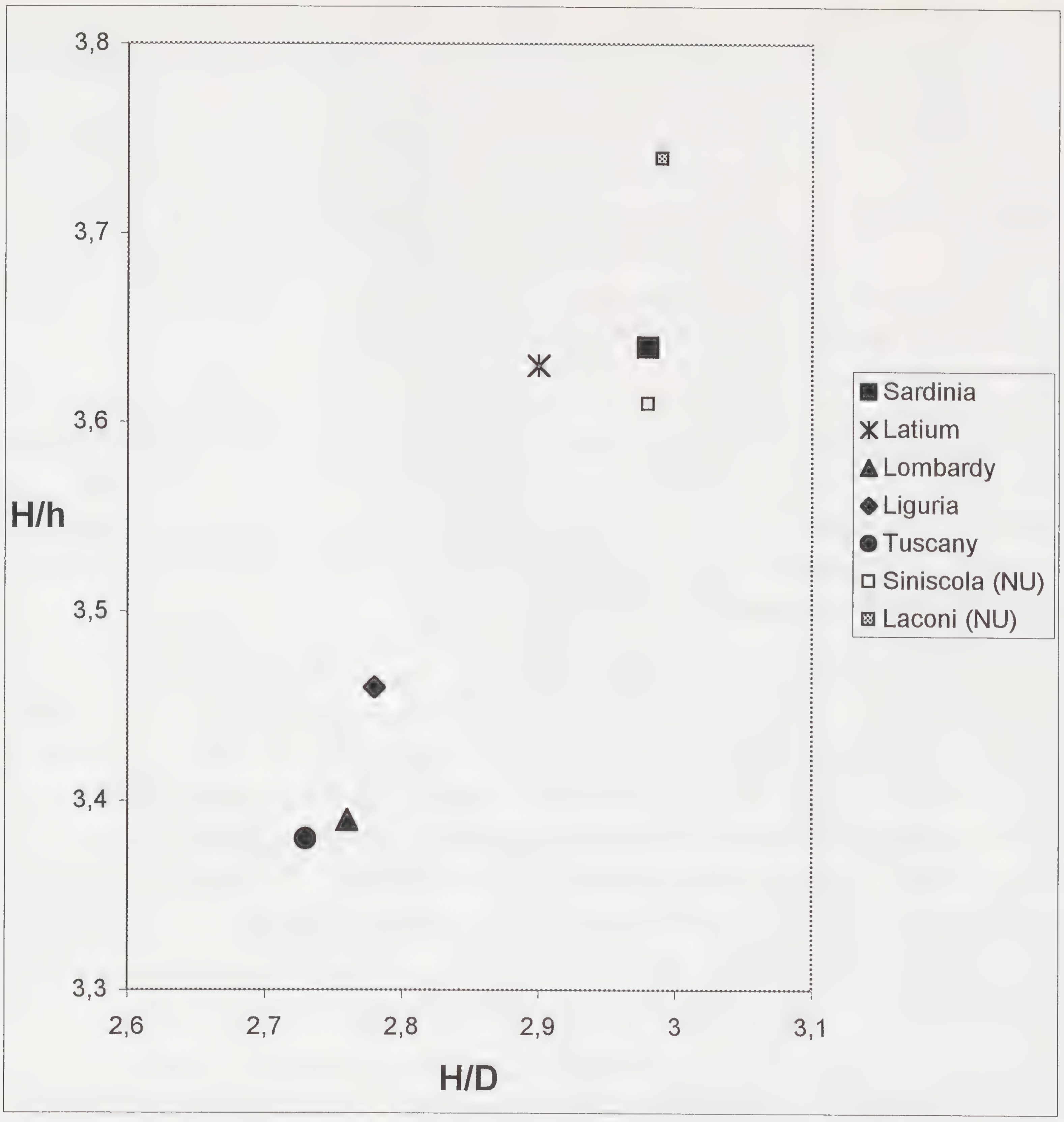


**Fig. 32** Distribution of mean ratios of shell height / aperture height (H/h) and shell height / shell diameter (H/D) of populations of *Platyla* sp. from Sardinia (and the populations from Siniscola and Laconi separately), of *P.* cf. *microspira* from Latium and of *P. microspira* from northern Italy (Lombardy, Liguria) and Tuscany. Populations as in Table 1.

eastern Sardinia (Siniscola) (Figs 10–11) with respect to those of central and western Sardinia (Alghero, Laconi e Iglesias) (Fig. 12). Specimens from central and western Sardinia have more evident a subsutural line and a more marked external peristomal rib (Figs 12, 26). Dimensions of specimens of the two groups are very similar (Table 1, Fig. 31), as is the ratio of shell height / diameter to shell height / aperture height (Fig. 32). This supports that these populations can be assigned to the same taxon.

This entity recalls *P. cryptomena* and *P. microspira* on the basis of the structure of the external peristomal rib (delimited posteriorly by a simple line), and *P. gracilis* on the basis of the cylindrical shell shape. It is distinguished from the latter, widespread in central-southern Europe (southern Germany, Austria, Italy, Balkan Peninsula; Boeters *et al.*, 1989: Fig. 118), by virtue of its lesser size and the structure of its external peristomal rib (*P. gracilis* is larger [height: 2.05–3.45 mm; diameter: 0.8–1.25 mm] and has the external peristomal rib delimited posteriorly by a sharp step; Boeters *et al.*, 1989, 119–124, Figs 117, 119–122, 135, 147, 148). It is distinguished from the Pyrenean *P. cryptomena* by virtue of its slightly smaller size, cylindrical shell and less developed external peristomal rib (*P. cryptomena* is larger [height: 2.5–3.2 mm] and has a more pupoid shell shape and a very large the external peristomal rib; Boeters *et al.*, 1989: 105–106, Figs 100–101, 104–105).

The relationship between *Platyla* sp. and *P. microspira* is more difficult to define. As far as is known, *P. microspira* lives in distant parts of southern Europe: Italy and Rumania. In mainland Italy, it is present only in Lombardy and a small area between Liguria and Tuscany; in Rumania it is only known from one locality of Transylvania (Boeters *et al.*, 1989). A group of populations resembling *P. microspira* was recently discovered in central Italy (southern Latium: Circeo and Monti Ausoni) (Fig. 30). These specimens (Figs 13–15, 22, 27–28) having a shell similar in size to that in *P. microspira* (Table 1, Fig. 31), but differing by virtue of more intense colouring and in shape (as shown by a different ratio of shell height / diameter to shell height / aperture height) (Table 1, Fig. 32) have been prudently referred to as *P.* cf. *microspira.*

The Sardinian specimens (Figs 10–12, 19–21, 31–32, Table 1) are similar to *P. microspira.* Nevertheless, they are distinguished by larger size, a shape slightly more elongate and cylindrical shape and more intense colouring (shell cylindro-conical and colourless or slightly coloured in *P. microspira;* Figs 16–18, 23–24, 29; Boeters *et al.*, 1989: Figs 129, 134, 166). They may be closer to *P.* cf. *microspira* from Latium: although larger (Table 1, Fig. 31), they have similar intense colouring and a similar ratio of shell height / diameter to shell height / aperture height (Fig. 32).

Concluding, two alternatives are possible. The Sardinian populations can be assigned by comparison to *P. microspira,* as done for those from southern Latium. Alternatively they can be assigned to new taxon on the basis of the differences in the shell characters described above (in standard terms of aciculid taxonomy such differences are sufficient to introduce a new taxon). The first option, which does not exclude conspecificity, is suggested by the fact that the differences between the Sardinian specimens and those from Lombardy and Tuscany are rather slight, especially in view of at least apparently intermediate position of the specimens from southern Latium. The second option is suggested by biogeographical considerations. The distinctive characters of the Sardinian populations may indicate divergence at species level due to long period of isolation.

It is impossible to decide between these two options and indeed both of them could be correct. We therefore abstain from deciding and leave these Sardinian populations indeterminate until other more significant characters (such as allozyme or DNA, because the anatomy is conservative through the entire family) will be available.

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## APPENDIX

Italian material examined of *P. microspira* from Lombardy, Liguria and Tuscany and of *P.* cf. *microspira* from Latium. Other localities in Lombardy (32TNR18, 32TNR38, 32TNR48, 32TNR57, 32TNR58) are reported by Boeters *et al.* (1989) and Eikenboom (1993, 1996).

Lombardy (*P. microspira):*
- Debris of Lago di Annone near Galbiate (Galbiate, Como), 32T NR 2873, M. Bodon leg. 7.10.1989 (2 sh MBC, 1 sh MZUF n. 16022).
- Monte Croce, Vo' di Moncodeno (Esino Lario, Como), 32T NR 2892, M. Bodon leg. 28.6.1991 (1 sh MBC, 1 sh SCC 4384/755).
- Avolasio, Val Taleggio (Vedeseta, Bergamo), 32T NR 48, S. Cianfanelli leg. 24.3.96 (1 sp, 7 sh SCC 7674/1175, 2 sh MZUF15916).
- Debris of Torrente Enna, Taleggio (Taleggio, Bergamo), 32T NR 48, S. Cianfanelli leg. 24.3.96 (20 sh SCC 7674/1176).
- Orrido di Bracca (Zogno, Bergamo), 32T NR 5373, M. Bodon leg. 31.7.1982 (1 sh MBC).
- 500 m west of Oltre il Colle (Oltre il Colle, Bergamo), 32T NR 5982, M. Bodon leg. 27.7.1992 (1 sp MBC).

Liguria *(P. microspira):*
- Spring of Canale di Redarca (Lerici, La Spezia), 32T NP 7480, M. Bodon leg. 21.1.1984 (1 sh) MBC.
- Debris of Canal Grande near the spring Fada (Ameglia, La Spezia), 32T NP 7680, M. Bodon leg. 15.3.1998 (8 sh MBC).
- Spring Fada (Ameglia, La Spezia), 32T NP 7680, M. Bodon leg. 15.3.1998 (1 sh MBC).

Tuscany (*P. microspira):*
- Debris of Fiume Magra, Villafranca in Lunigiana (Pontremoli, Massa Carrara), 32T NQ 753 052, M. Bodon leg. 29.5.1993 (8 sh MBC).
- Debris of Fiume Magra near la Chiesaccia, Lusuolo (Mulazzo-Villafranca in Lunigiana, Massa Carrara), 32T NQ 760 009, M. Bodon leg. 26.10.1994 (4 sh MBC, 1 sh MZUF 15917).
- Debris of Fiume Magra upstream of Ponte Quarlieri, Terrarossa (Tresana, Massa Carrara), 32T NP 762 986, M. Bodon leg. 14.3.1992 (1 sh MBC).
- Debris of Fiume Magra, Isola, Albiano (Aulla, Massa Carrara), 32T NP 742 930, M. Bodon leg. 22.12.1991 (2 sh MBC).
- Debris of Fiume Magra, 300 m west of Isola, Albiano (Aulla, Massa Carrara), 32T NP 738 929, M. Bodon leg. 29.10.1995 (1 sh MBC).

Latium (*P.* cf. *microspira):*
- Monte Circeo, Le Crocette (S. Felice Circeo, Latina), 33T UF 3966, M. Bodon leg. 5.4.1996 (5 sp, 11 sh MBC, 1 sh MZUF no. 11569, 3 sh MZUF no 11583).
- Monte Circeo, Quarto Freddo (S. Felice Circeo, Latina), 33T UF 3567, M. Bodon leg. 5.4.1996 (1 sp, 1 sh MBC).
- Valle Viola, Val Marina, (Monte S. Biagio, Latina), 33T UF 5681, M. Bodon leg. 8.4.1996 (1 sp, 3 sh MBC).

# WEEDS AS A SUPPLEMENTARY OR ALTERNATIVE FOOD FOR *ARION LUSITANICUS* MABILLE (GASTROPODA: STYLOMMATOPHORA)

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*Abstract* *Susceptibility of 30 weed species to* A. lusitanicus *feeding was evaluated under natural conditions in two successive vegetation seasons (1997–1998). Observations were conducted on the number and degree of plant injuries, and as a result 13 weed species were found to be most frequently and most heavily injured. Food preference of slugs for 10 selected weed species and 8 cultivated plant species was determined under laboratory conditions. It was found that the most frequently and most seriously damaged under field conditions was* Aegopodium podagraria *L. — this and other weeds can be an alternative food for the slug. A comparison of the number of seedlings of the studied species eaten showed a high susceptibility of* Galinsoga parviflora *Cav.,* Brassica napus *L. and* Helianthus annuus *L. to slug feeding.*

*Key words* *Weeds,* Arion lusitanicus, *plant susceptibility to feeding.*

## INTRODUCTION

*Arion lusitanicus* Mabille, 1868 like many other harmful slug species occurring in Poland is an omnivorous species. It feeds on live, decomposing and dead plants, small invertebrates and faeces of other animals. The basic food of the slug is cultivated plants, chiefly vegetables and some species of cereals, legumes and root crops, oilseed, horticultural and ornamental plants (Kozłowski, 1995). The slug also willingly eats different species of herbaceous plants growing in non-crop areas, including scrub and forest (von Proschwitz, 1994). During the studies on the occurrence and harmfulness of *A. lusitanicus* in Poland (Kozłowski, 1995), many cases of heavy weed destruction by the slug were observed.

Previous observations have shown a marked feeding preference of the slug for some cultivated plants (Kozłowski & Kozłowska, 1998a, 1998b). The purpose of the present studies was to determine the attractiveness of wild plants to the slug.

## MATERIALS AND METHODS

Studies on weed damage caused by *A. lusitanicus* were conducted in 1997–1998 in the regions of Rzeszów (EA 74), Łańcut and Albigowa (EA 84). The observation sites were horticultural crops and adjacent areas (ditches, meadows, non-crop areas and brushwoods). The weed species which the slug fed on, as well as the number and degree of plant injuries, were determined. In total, 30 weed species were examined.

The acceptability of seedlings of 10 weed species and 8 cultivated plant species by the slug was determined under laboratory conditions at a day temperature of 19.5 ºC, night temperature of 16.5 ºC, Relative Humidity 95% and 15 hour day length. Seeds of the 18 plant species were sown in 9 plastic containers filled with soil, 10 seeds of each of 6 plant species being sown into each container (incomplete block design). When the plants achieved the 2–3-leaf stage, 5 slugs of 4 months old and weighing on average 930 mg were starved for 48 hours (reared in the laboratory) and placed in each container. The percentage of seedlings of each species (cultivated plants and weeds were similar in size) eaten by the slug was determined. The results were statistically analysed (analysis

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of variance, Fisher-Snedecor's test and Tukey's test, $\alpha=0.05$). Palatability indices (Pl) were also estimated for each studied plant from the ratio: logarithm of eaten seedlings to logarithm of a reference seedling (Cates & Orians, 1975).

## RESULTS AND DISCUSSION

The field observations showed that 13 out of 30 studied weed species were injured by *A. lusitanicus* (Table 1). It was also found that the degree of plant damage to particular weed species varied greatly. The most frequently and most heavily injured plant was ground elder, *Aegopodium podagraria* L. This troublesome weed from the family Umbelliferae, the leaves of which are sometimes eaten by humans in spring, was completely eaten by the slug. The degree of plant destruction was so large that by summer, in places of a mass occurrence of *A. lusitanicus,* this weed was almost absent. Other heavily injured weed species are: cockspur, *Echinochloa crus-galli* (L.) P.B. (Gramineae), gallant soldier, *Galinsoga parviflora* Cav. (Compositae), common poppy, *Papaver rhoeas* L. (Papaveraceae) and tansy, *Chrysanthemum vulgare* L. (Compositae). Tansy was particularly readily eaten by juveniles of *A. lusitanicus* in the spring in the vicinity of their winter shelters. In the spring the slugs also readily fed on other dicotyledonous weeds such as: those already mentioned, greater burdock, *Arctium lappa* L. (Compositae), cut-leaved cranesbill, *Geranium dissectum* L. (Geraniaceae) and stinging nettle, *Urtica dioica* L. (Urticaceae). These weeds were also frequently eaten by the slug in the period of crop ripening. Despite a large abundance of vegetables, which were the main food of the slug, it readily fed on weeds growing on strips, in ditches and dense bushes adjacent to crops. The remaining weed species mentioned in Table 1 were also injured by the slug, but significantly less frequently. In Sweden, besides vegetables, *A. lusitanicus* heavily injures some herbs, such as: dog's mercury, *Mercurialis perennis* L. (Euphorbiaceae), red campion, *Melandrium rubrum* L. (Caryophyllaceae), bittersweet, *Solanum dulcamara* L. (Solanaceae) and Solomon's seal, *Polygonatum multiflorum* (L.) (Liliaceae). As reported by von Proschwitz (1994), these plants were completely devoid of leaves as a consequence of slug feeding. In our studies, *A. lusitanicus* was not observed to feed on mature grasses, with few exceptions. Also this species fed only

TABLE 1

Weed species injured by *A. lusitanicus* (+++ plants completely damaged,++ plants very heavily damaged, + plants heavily damaged)

| Species of plant | Family | Parts eaten | Degree of damage |
|---|---|---|---|
| 1. *Aegopodium podagraria* L. | Umbelliferae | cotyledons, leaves | +++ |
| 2. *Arctium lappa* L. | Compositae | leaves | + |
| 3. *Echinochloa crus-galli* (L.) P.B. | Gramineae | cotyledons | ++ |
| 4. *Galinsoga parviflora* Cav. | Compositae | leaves | ++ |
| 5. *Geranium dissectum* L. | Geraniaceae | leaves | + |
| 6. *Lamium album* L. | Labiatae | leaves | + |
| 7. *Matricaria chamomilla* L. | Compositae | cotyledons, leaves | + |
| 8. *Papaver rhoeas* L. | Papaveraceae | cotyledons, leaves | ++ |
| 9. *Rumex crispus* L. | Polygonaceae | leaves | + |
| 10. *Stellaria nemorum* L. | Caryophyllaceae | leaves | + |
| 11. *Chrysanthemum vulgare* L. | Compositae | leaves | ++ |
| 12. *Tripleurospermum inodorum* L. | Compositae | leaves | + |
| 13. *Urtica dioica* L. | Urticaceae | leaves | + |

TABLE 2

Percentage of seedlings of cultivated plants (1 to 8) and weeds (9 to 18) eaten by *A. lusitanicus* (corrected means) and results of Tukey's test, $\alpha$=0.05

| **Plants** | **Feeding day number** | | | | | |
|---|---|---|---|---|---|---|
| | 3 | | 5 | | 7 | |
| 1. *Triticum vulgare* Vill. | 12.4 | ef | 28.8 | cd | 42.5 | e |
| 2. *Hordeum vulgare* L. | 50.6 | bcdef | 66.1 | abc | 84.7 | abc |
| 3. *Brassica napus* L. | 22.3 | def | 60.3 | abc | 100.0 | a |
| 4. *Helianthus annuus* L. | 59.5 | abcd | 91.8 | a | 100.0 | a |
| 5. *Trifolium resupinatum* L. | 50.4 | bcdef | 73.6 | ab | 99.6 | a |
| 6. *Medicago sativa* L. | 48.0 | bcdef | 70.3 | ab | 95.5 | ab |
| 7. *Vicia sativa* L. | 60.9 | abcd | 82.8 | ab | 96.4 | a |
| 8. *Beta vulgaris* var *crassa* L. | 13.6 | ef | 47.9 | bcd | 75.5 | bcd |
| 9. *Galinsoga parviflora* Cav. | 99.7 | a | 97.8 | a | 100.0 | a |
| 10. *Capsella bursa-pastoris* (L.) Med. | 49.4 | bcdef | 60.1 | abc | 81.9 | abc |
| 11. *Chenopodium hybridum* L. | 31.0 | cdef | 63.4 | abc | 88.6 | ab |
| 12. *Tripleurospermum inodorum* L. | 55.6 | abcde | 83.4 | ab | 94.3 | ab |
| 13. *Galium aparine* L. | 8.1 | f | 21.1 | d | 61.4 | de |
| 14. *Matricaria chamomilla* L. | 62.3 | abcd | 83.8 | ab | 91.8 | ab |
| 15. *Papaver rhoeas* L. | 68.3 | abc | 85.3 | ab | 96.4 | a |
| 16. *Anthemis arvensis* L. | 34.4 | bcdef | 69.7 | ab | 95.0 | ab |
| 17. *Taraxacum officinale* L. | 27.1 | cdef | 48.0 | bcd | 64.4 | cd |
| 18. *Echinochloa crus-galli* (L.) P.B. | 77.9 | ab | 79.6 | ab | 90.2 | ab |

The same letter indicates no significant difference between plants

slightly on some weeds, which are frequently injured by other slug species. For example, it slightly injured shepherd's purse, *Capsella bursa-pastoris* (L.) Med. (Cruciferae) or groundsel, *Senecio vulgaris* L. (Compositae), which are strongly injured by *Deroceras sturanyi* Simroth (Kosińska, 1980). Cook *et al.* (1997) observed that *D. reticulatum* slugs, which had not experienced wheat seedlings before, preferred *Taraxacum officinale,* and they suggested its use for slug control in winter wheat by providing dandelion strips growing at the field edges. *Arion lusitanicus,* like some other slug species, did not attack *Plantago lanceolata* L. (Plantaginaceae) plants. This weed contains substances, such as caffeic acids, which are disliked by slugs and protect *P. lanceolata* seedlings from injury (Molgaard, 1988). Nevertheless, as shown by the studies of Kosińska (1980), leaves of that weed are readily eaten by *D. sturanyi.* This may indicate that *D. sturanyi* has developed a protective response to these unfavourable plant substances. Substances of some plant species may be deterrent to *A. lusitanicus.* Barone and Frank (1999) showed that extracts from *Saponaria officinalis* and *Valerianella locusta* effectively reduce feeding of *A. lusitanicus* on young plants of rape.

Laboratory analysis of feeding preference of *A. lusitanicus* for seedlings of 18 different crop and weed species showed no differences in slug damage after 24 hours. Significant differences in the percentage of plant seedlings eaten by slugs were noticed only three days after feeding (Table 2). Most injured were seedlings of *Galinsoga parviflora* and *Echinochloa crus-galli,* whereas the least damaged were seedlings of cleavers, *Galium aparine* L. (Rubiaceae), wheat *Triticum vulgare* Vill. (Graminaceae) and beet, *Beta vulgaris* var. *crassa* L. (Chenopodiaceae). Seven days after slug feeding it was found that seedlings of *Galinsoga parviflora,* rape, *Brassica napus* L. (Cruciferae) and sunflower, *Helianthus annuus* L. (Compositae) were all eaten and wheat seedlings, *Triticum vulgare* down to 42.5%. Among the studied weed species the least damaged by *A. lusitanicus* were seedlings of *G. aparine* (61.4%) and *T. officinale* (64.4%), however the damage was significant (Figs. 1, 2). Other weed seedlings were damaged by the slug to over 80%.

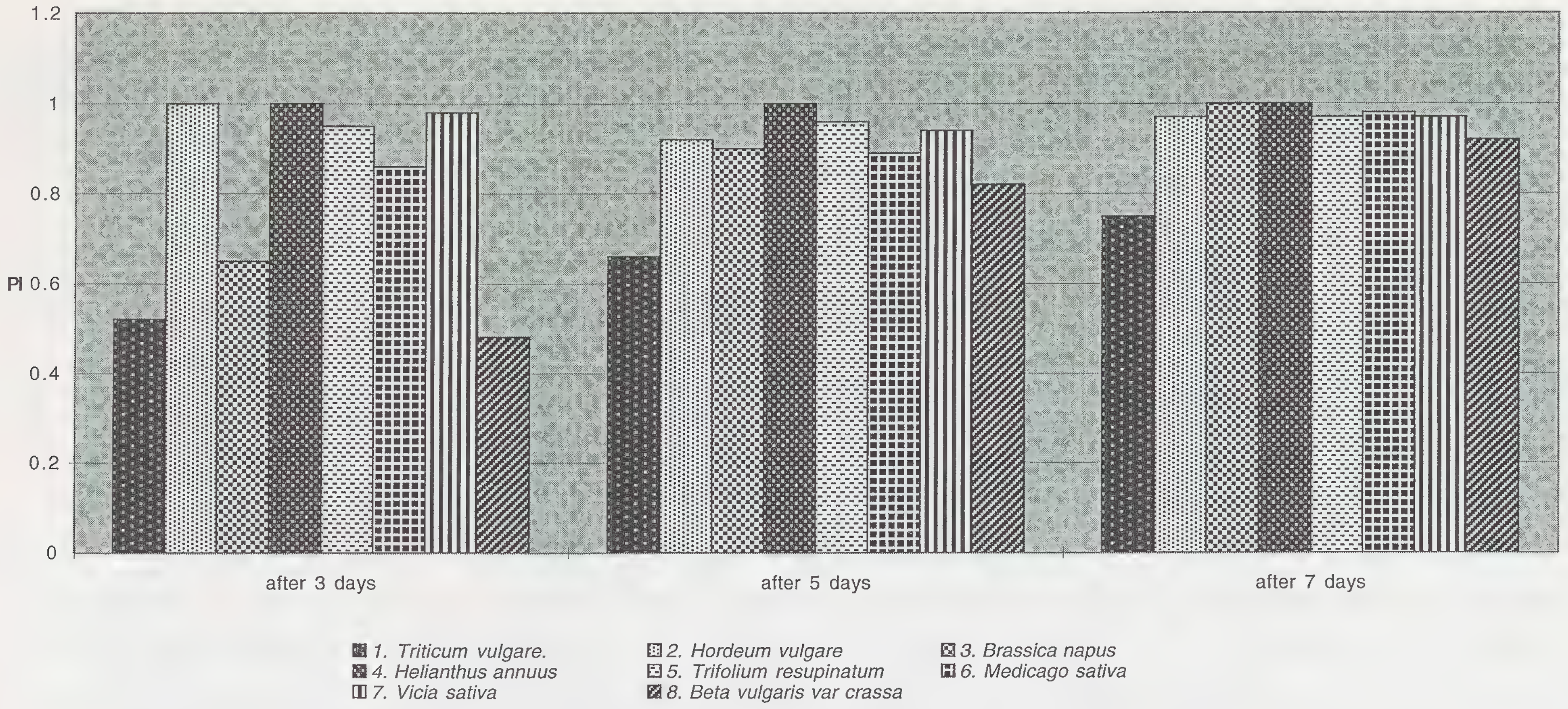

**Fig. 1** Palatability indices (PI) of crop seedlings for *Arion lusitanicus* Mab.

To determine the palatability index Pl, the most readily eaten species of cultivated plants or weeds were chosen as controls — for cultivated plants (Fig. 1) that was *Helianthus annuus*, and for weeds (Fig. 2) *Galinsoga parviflora*. The largest differences between palatability indices were found three days after slug feeding. After 3 days, the palatability indices increased because the slugs had eaten the most palatable species (which was the reference species) and then turned to less palatable species such as *B. vulgaris* and *C. hybridum*. This is supported by earlier reports that slugs can eat unacceptable food (Whelan, 1982). Small declines of the index values result from the incomplete block design.

Results obtained in laboratory experiments concerning weed susceptibility to *A. lusitanicus* feeding are principally in agreement with field observations. They suggest that *Arion lusitanicus* has notable preferences for some weed species, and can completely destroy some populations of some weeds. According to Frank and Friedli (1999) some weed species, for example, *Capsella bursa-pastoris* and *Taraxacum officinale* are as attractive for *A. lusitanicus* as rape and feeding of that slug on *Veronica persica* significantly reduces the number of damaged rape plants. Briner and Frank (1998) in their studies on the palatability of the foliage of 78 species of sown and naturally occurring plants also showed that besides rape, the weeds *Papaver rhoeas, C. bursa-pastoris* and *Lamium*

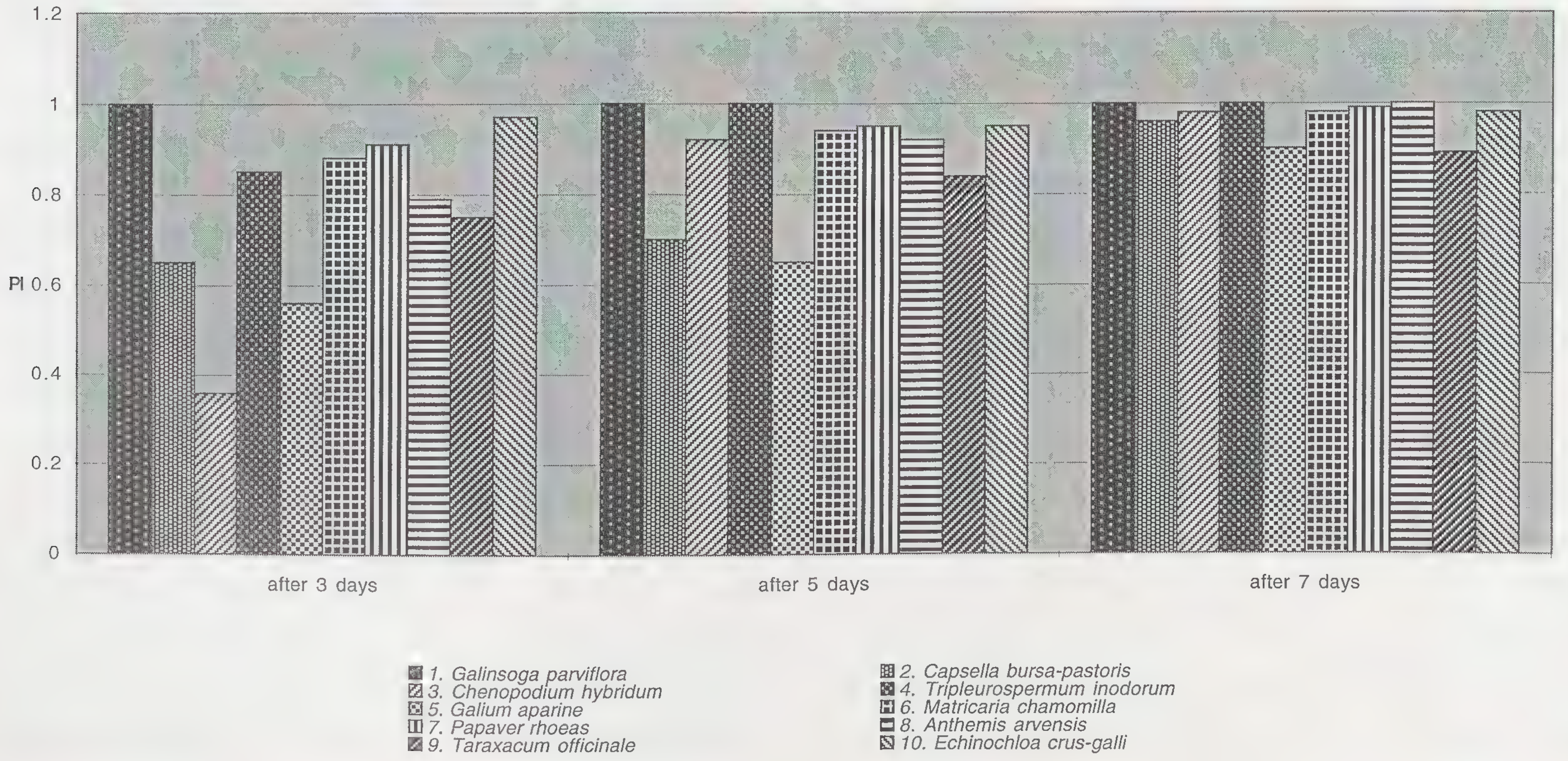

**Fig. 2** Palatability indices (PI) of weed seedlings for *Arion lusitanicus* Mab.

*purpureum* belong to species most readily eaten by *A. lusitanicus*. From this it follows that weeds may be a supplementary or alternative feeding for *A. lusitanicus*. Similar observations were obtained with regard to *D. reticulatum* by Cook *et al.*, (1996). They found that slug feeding on weeds (*T. officinale, C. bursa-pastoris, Trifolium repens* and *Chenopodium album)* reduced damage to winter wheat. Moreover, Frank and Friedli (1999) observed that feeding of *D. reticulatum* on *C. bursa-pastoris* may significantly reduce slug feeding on rape. In some habitats, weeds will be the main food of *A. lusitanicus*. This will be the case of individuals inhabiting forests or brushwoods far away from cultivated plants (von Proschwitz, 1994).

In field crops, slugs can choose many plant species, both cultivated and wild, on baulks and at field edges. The observed high attractiveness of some weed species points to the existence of a potential possibility of using them as alternative food for harmful slugs to protect young cultivated plants from damage.

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# *VERTIGO MOULINSIANA* IN KENT

The Des Moulin's whorl snail, *Vertigo moulinsiana* (Dupuy, 1849) is listed in the British Red Data Book as an RDB3 (Rare) species, is scheduled on Annex II of the European Habitats & Species Directive and is included on the UK Biodiversity Action Plan list of priority species. In Britain *V. moulinsiana* is locally distributed across southern and eastern England from Dorset to north Norfolk with a few isolated colonies elsewhere (see Kerney 1999[1]; Drake 1999[2]). The distribution given by these authors shows that *V. moulinsiana* is absent from south-east England with no records east of western Sussex and Surrey. However, there are many records from tufa deposits which show that it was very common in Kent during the Postglacial (Kerney 1999). Nevertheless it was a great surprise when it was discovered living at Westbere Marshes, Kent in August 1999, amongst a sample of freshwater molluscs collected from an overgrown grazing marsh ditch.

As a result of the discovery of this site, well outside its known range in England, a further survey was carried out on behalf of English Nature to determine the size and extent of the population. The survey focused on two areas adjacent to the River Great Stour within Stodmarsh SSSI in 1km national grid squares TR1960 and TR2060:

1) Grazing marshes on the south side of the River Great Stour (from where the original specimens were discovered) comprising 'semi-improved', cattle-grazed grassland intersected by drainage ditches, most of which drain into the river. Most of the ditches were in an advanced stage of vegetational succession with margins of mainly dense *Glyceria maxima*, and in some, *Carex acutiformis.*

2) Westbere Marshes on the north side of the River Great Stour, south of Westbere village. The survey area focused on habitats to the south and east of a large flooded gravel pit. These included a ditch running parallel to the river with *Phragmites australis, Phalaris arundinacea, G. maxima* and tall herbs, flooded lake margins with alder and willow carr and some open areas of fen with mainly *P. australis* and *C. acutiformis,* extensive area of marsh dominated by *P. australis, G. maxima,* and open willow/alder carr intersected by a network of drainage ditches. All sites were ungrazed but some of the reed beds are cut.

The results of the survey showed that *V. moulinsiana* was widely distributed within the survey area, and in places, was locally abundant. On the south side of the river the snail was found in 9 of the 14 sample locations. Whilst the snail was widespread across the site, the core of the population was located along three ditches in the central part of the area. Although all of these ditches had been recently cleared, broad fringes of *C. acutiformis* and *G. maxima* remained undamaged. In these ditches, *V. moulinsiana* was either common or abundant and in some cases the counts per sample compared favourably with large populations elsewhere such as those in the Lambourn valley, Berkshire (e.g. Killeen & Stebbings 1999[3]). In most of the samples juveniles outnumbered adults by a factor of at least 2:1, suggesting healthy recruitment, and which again compares favourably with results obtained in the Lambourn at a similar time of year. On the north side of the river *V. moulinsiana* was found to be widespread and locally common, being found in a range of habitats including overgrown ditches, fen/carr at lake margins, and open areas of reedbed with *G. maxima.*

General management and conservation issues for *V. moulinsiana* are summarised by Drake (1999). Given that the snail is widespread and locally common on Westbere Marshes, unless there are significant changes to existing management practice, there is no immediate threat. However, the population on the south side of the river is potentially at risk, being vulnerable to ditching operations.

This work was carried out with financial support from English Nature which is gratefully acknowledged.

[1] KERNEY M.P. 1999 *Atlas of the land and freshwater molluscs of Britain and Ireland* Harley Books.

[2] DRAKE C.M. 1999 *J. Conch.* **36**: 63–79.

[3] KILLEEN I. & STEBBINGS R.E. 1999 A34 Newbury bypass. Results of monitoring the translocated habitat for *Vertigo moulinsiana.* Unpublished report to Mott MacDonald, Winchester.

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# NOMENCLATURAL RECTIFICATIONS FOR INDO-PACIFIC LUCINIDAE

The purpose of this note is to rectify the nomenclature of a genus and species of Indo-Pacific bivalve of the family Lucinidae. Unfortunately, *Rastafaria,* the name we proposed for an unusual lucinid bivalve with long periostracal pipes is preoccupied by its prior use for an insect and requires a replacement which is given below. Additionally, there is an earlier species name available for *Rastafaria calypso* Glover & Taylor[1], 1997, a species we recently described from the northern Indian Ocean and Red Sea.

### Genus ***Rasta*** nom. nov.

*Rastafaria* Taylor & Glover[2], 1997 not *Rastafaria* Ramme[3], 1931: 931 (Insecta: Orthoptera: Acrididae).

### ***Rasta lamyi*** (Abrard, 1942)

*Saxolucina (Megaxinus) lamyi* Abrard[4], 1942: 39, pl. 4, figs 25 & 26. Pleistocene fossil, type locality: Ravin de Baghenda, 1500m W. of Obock, Djibouti.
*Rastafaria calypso* Glover & Taylor, 1997: 3, figs 2 & 3a-c.

Although *Saxolucina lamyi* was described from a single right valve from Pleistocene rocks, the excellent figures confirm that it is conspecific with *R. calypso* and the name thus has priority.

We thank Hubert Blatterer for pointing out that the name *Rastafaria* Taylor & Glover is preoccupied and Henk Dekker for drawing our attention to the Abrard paper.

[1] GLOVER E.A. & TAYLOR J.D. 1997 *J. Conch.* **36**: 1–18.

[2] TAYLOR J.D. & GLOVER E.A. 1997 *The Marine Flora and Fauna of the Houtman Abrolhos Islands, Western Australia* Western Australian Museum, pp 335–361.

[3] RAMME W. 1931 *Mitt. Zool. Mus. Berl.* **16**: 918–945.

[4] ABRARD R. 1942 *Archs Mus. natn Hist. Nat. ser. 6,* **18**: 5–105.

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# *ENSIS MINOR* (CHENU, 1843) IN CARDIGAN BAY

One hundred complete fresh shells of *Ensis* were collected from Shell Island (Cardigan Bay, Wales), about 5 miles south of Harlech (map ref. SH555265) on 5/4/1999. Amongst these was one recently dead specimen with the animal intact. All shells were measured following Van Urk's methods[1] and 90% appear to fall within *E. minor.* Rudo von Cosel at the Natural History Museum in Paris has seen examples of the shells and confirmed my identification. One of the major identifying features was the compressed posterior gape of the shells. *Ensis minor* has been found in the Firth of Forth[2] and on the Netherlands coast[1]. This is the first record of *E. minor* on the western coast of Britain but it may have been overlooked by previous recorders.

I now intend to re-examine *Ensis* collections and any help in examining further *Ensis* shells from other sites around the British Isles would be appreciated.

I also wish to thank Jan Light for her assistance.

[1] Van Urk R.M. 1964 *Basteria* **28** 13–44.

[2] Smith S.M. 1970 *J. Conch.* **27** 127–129.

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# BOOK REVIEWS

*Atlas of the land and freshwater molluscs of Britain and Ireland* by Michael Kerney 1999. Harley Books, Colchester. 261pp. ISBN 0-946589-48-8. Cost £25. Discount available to members of the Conchological Society.

The eagerly awaited second edition of "the atlas" has finally appeared, 23 years after its forerunner, to the great delight of those who have contributed to the mapping scheme over the years. So how does the new compare with the old? The new edition has a smaller format, a hard cover and reliable binding. The introductory text is far more extensive and reviews the 'Early history of recording', 'The Mapping scheme' (its origin, field procedures and completeness), 'Factors influencing distributions' and 'The history of the British fauna'. The new format, identical to other atlases published by Harley Books, allows space for brief comments on habitat, history and status (including Red Data book criteria where appropriate) to accompany the distribution maps for each species. Drawings of each species appear as vignettes in the top left-hand corner of each map. These have been culled from various sources (some have been specially drawn) and are a welcome addition, although the quality of the images is somewhat variable. Following the 'Distribution maps and species accounts', which obviously form the main component of the book, are six further maps of environmental factors that influence many of the distributions (January and July mean temperatures, Annual rainfall, Calcareous rocks, Maximum altitude and Sulphur dioxide). Every locality mentioned in the text is then listed together with its 10 km grid reference. An exhaustive list of recorders follows, although it is worth noting that most of the new records that appear in this Atlas were submitted by a tiny subset, perhaps no more than about 40 dedicated enthusiasts. I mention this in case others are deterred from initiating a comparable scheme by what appears to be an impressively large work-force. The Atlas concludes with a select Bibliography of over 200 references and a useful Index that lists synonyms in italics alongside species names, still current.

As in the first edition, the distribution maps have been plotted on a 10 km square basis (using technology made available at the Biological Records Centre, ITE, Monks Wood). Three symbols appear on the maps: records made in or after 1965, records made prior to 1965 (the majority of these belong to the period 1880-1914) and fossil occurrences (Lateglacial and Postglacial). The maps therefore differ from those of the first edition in plotting as old records those earlier than 1965 rather than those earlier than 1950, and in showing Lateglacial, as well as Postglacial (=Flandrian) records for all species, rather than just a select few. This has resulted in the inclusion of maps for several species (e.g. *Columella columella, Discus ruderatus, Nesovitrea petronella, Cochlicopa nitens, Trochoidea geyeri, Helicopsis striata, Margaritifera auricularia* and *Pisidium vincentianum)* that have never been found living in the British Isles in historical times. Although the Atlas focuses specifically on land and freshwater species, a few semi-marine snails of saltmarsh and brackish water are also mapped, including three *(Heleobia stagnorum, Truncatella subcylindrica* and *Paludinella littorina)* that were omitted from the first edition. Greenhouse aliens and chance 'casuals' have been excluded, as have records of a few introduced species that flourished briefly before dying out (e.g. *Cernuella neglecta* at Luddesdown, Kent). The nomenclature has been updated in line with continental usage but such changes are conservative and have been kept to an absolute minimum.

At the outset of the mapping scheme in 1965, the intention was to record an average of 60% of the estimated species living in each 10 km square. The new coverage map is certainly impressive and suggests that this target has largely been achieved for most parts of the British Isles. Comparison of the coverage maps in the two editions shows substantial improvement, particularly for parts of Ireland and Scotland. Many of these new records have resulted directly from specially organized mapping expeditions by members of the Conchological Society. Some regions have been mapped intensively, especially those counties that have undertaken tetrad surveys (Devon, Cardigan, Bedfordshire, Suffolk and the Isle of Wight). Other areas remain poorly known (Nottinghamshire and Staffordshire). Despite these biases, the coverage is now sufficiently good to allow confidence in the reality of the maps.

The maps provide excellent data that should enable us to formulate hypotheses about controlling factors. Many maps can be interpreted in terms of geology or climate and are an elegant confirmation of the primacy of these factors in controlling distributions. Many calciphile species (e.g. *Pomatias elegans)* show a strong affinity for chalkland soils. Others, such as *Pyramidula rupestris,* demonstrate a liking for other sorts of limestone, particularly the Carboniferous Limestone, although the accompanying map of Calcareous rocks does not allow such discrimination. Not surprisingly, the calcifuge *Zonitoides excavatus* shows a general avoidance of any limestone substrate. One unexpected finding is the aversion that some species *(Trichia striolata* and *Lauria cylindracea)* appear to show to the Triassic bedrock of the Midlands. Other distributions are obviously determined by climate. The distribution of *Perforatella subrufescens,* for example, coincides with areas of highest annual rainfall. Other distributions are less easily explained, that of *Ashfordia granulata* presenting a particularly perplexing problem.

Additional species have been added to the British fauna. Since 1976, one aquatic species *(Ferrissia wautieri),* four species of land snail *(Vertigo genesii, Vertigo modesta, Perforatella rubiginosa* and *Paralaoma caputspinulae)* and one species of slug *(Tandonia rustica)* have been discovered living in the British Isles for the first time. The three records of *Corbicula fluminea* from East Anglia were discovered too late for inclusion.

A further outcome of the mapping scheme has been the stimulation of research into the taxonomy of various poorly known groups, especially certain families of slug. The systematics of arionid slugs, in particular, has undergone something of a revolution in the last twenty years and the maps for certain segregates in this group are consequently the least satisfactory in the entire Atlas. Tetrad surveys conducted during the last 20 years have separated these newly recognized taxa but this has not been done generally. Consequently, these segregate maps tend to reflect the location of these new surveys, rather than 'real' distributions. Devon is not therefore an arionid hotspot! No attempt has been made to map the distributions of the segregate species of *Lymnaea.* Molecular and other evidence suggests that both the *palustris* and *peregra* groups are comprised of a number of genuine species. It is therefore ironic that we still cannot identify what are likely to be our most widespread species of aquatic snail.

One of the important objectives of mapping is to illuminate change and this is why old and fossil records are included in the survey. Some alarming patterns emerge, which give rise to serious conservation concerns. For example, *Myxas glutinosa* and *Segmentina nitida* have contracted their ranges dramatically during the last century. It is imperative to understand the precise causes of these declines if we are to save the species as part of our fauna. *Lymnaea glabra* has also declined significantly but far less dramatically. Amongst the land snails, *Leiostyla anglica, Spermodea lamellata* and several species of *Vertigo (pusilla, substriata, moulinsiana, genesii, geyeri, alpestris* and *angustior)* show evidence of long-term decline, whereas other species *(Balea perversa, Helicigona lapicida, Pupilla muscorum* and *Helicella itala)* appear to have disappeared from many sites in eastern England during the last hundred years. Readers may be puzzled by the increased number of pre-1965 records on some of the new maps. This does not always reflect the discovery of new populations of dead shells but rather the more assiduous abstraction of records from the older literature and especially from unpublished notebooks. Not all the maps present such a gloomy picture. A few introduced species appear to have expanded their ranges during the last 25 years. *Hygromia limbata* and *H. cinctella* have both spread beyond their South Devon strongholds. The latter, first noted in Paignton in 1950, has established colonies in Worcestershire and has extended eastwards as far as Kent. The vermiform slug, *Boettgerilla pallens,* has spread in even more spectacular fashion and is now distributed over most parts of the British Isles, since its first discovery here in 1972.

The Atlas is the culmination of nearly 40 years work by members of the Conchological Society. The success of the mapping scheme can be attributed to two main factors. First, the simplicity of its field procedure, which enabled the participation of a central core of enthusiatic amateurs. Second, the whole venture has been coordinated since its inception by Michael Kerney. The records submitted to him, as Non-marine Recorder, have all been carefully scrutinized and dubious records deleted, unless supported by voucher specimens. The role has been far from passive and has required both patience and tact. To ensure the accuracy of records, he has essentially provided an informal identification service and he has become famous for answering enquiries by return post. This has required enormous dedication and the success of the scheme stems largely from this commitment.

Most people involved with the mapping scheme will already have purchased their copy of the Atlas and this review is intended to entice those less directly involved or readers from abroad. The publication of this Atlas is an important milestone that I hope will have two direct consequences. First, I hope it will inspire people to initiate comparable schemes in those European countries where these do not exist. Second, if this happens, I hope that one day I will own an Atlas showing molluscan distributions for the whole of Europe, plotting maps on a 50 km square basis. Such atlases already exist for plants (Atlas Flora Europaea) and mammals (The Atlas of European mammals, Poyser Natural History). This Atlas of the land and freshwater molluscs the British Isles is a valuable contribution to this end.

Richard Preece

*Fauna Helvetica 2. Atlas der Mollusken der Schweiz und Liechtenstein* by Hans Turner, Johannes G J Kuiper, Nigel Thew, Reno Bernasconi, Jorg Rüetschi, Max Wütrich and Margret Gosteli. Centre Suisse de cartographie de la faune 1998 (CSCF/SZKF), Schweizerische Entomologische Gesellschaft (SES/SEG), Terreaux 14, CH-200O, Neuchatel, pp 1–527. ISBN 2-88414-013-1 / ISSN 14 22 6367. Price SFr 70 +SFr 10 p&p.

This impressive and important distribution mollusc atlas is the second volume in the *Fauna Helvetica* series, the first being a Diptera checklist. It is the result of a project launched on in l981 although the bulk of record accumulation took place between l988 and 1997. The basis of the work is 279 distribution maps using the 5x5 Km square as a mapping unit (four times as fine a grid as the Great Britain and Ireland scheme) to cover indigenous freshwater and land mollusc species, subspecies and segregates.

But there is much more to it than that. There are sections on the history of malacological research in Switzerland, on the mapping project itself, on Switzerland as a molluscan habitat, together with a systematic list of Quaternary and Recent molluscs and other sections on temporary introductions and greenhouse aliens, uncertain records and species only recorded as Pleistocene and Postglacial fossils, a summary of the content and unresolved problems in four languages including English, a useful German, French, Italian, English vocabulary, a list of institutions and individuals holding material, a bibliography and indexes of French and German vernacular names and scientific names.

Each map is accompanied by text covering synonyms, global and Swiss and Liechtenstein distribution, altitudinal range, ecology and biology, and conservation "Red Listing" in respect of Switzerland, Bavaria, and Austria, and a black and white photograph (except for the slugs, illustrated in the colour plates). There are 67 excellent colour photographs of living land molluscs, plus 12 of shells (mainly umbilical views of *Trichia* species, but also *Sphaerium corneum*). Maps are not given for the temporary introductions and greenhouse aliens, for the doubtfully recorded species, uncertain records, or for the Pleistocene and Postglacial fossils not found living in the area.

Records are distinguished on the maps mainly by date: 42000 for 1951-57, 13000 for 1901-1950, 11000 pre-1901, plus 1000 fossil records and 100 undated from literature. Given that the mapping unit is a 5x5 Km square, this enables production of a good picture of the areas in which a species is to be found even if it does not result in solidly filled-in maps for species which are virtually ubiquitous over much of the country, for example *Aegopinella nitens.*

The fauna of the area is very much controlled by the terrain and its underlying geology; many of the maps show this excellently; examples include *Cochlostoma septemspirale* (Razoumousky, 1789)(p.71), *Trichia montana* (Studer, 1820) p. 342), *Retinella hiulca* (Albers, 1850) (p.268), and *Oxychilus helveticus* (Blum, 1881) (p.277). Ten species were added to the area's fauna as a result of the mapping project, and a further 12, previously poorly known there were better documented. Taxonomic treatment of species differs somewhat from that adopted in Kerney 1999[1] For instance *Stagnicola* species are mapped separately as *Stagnicola corvus* (Gmelin, 1791), *S. fuscus* (Pfeiffer, 1821) and *Stagnicola* sp indet. and *Pupilla bigranata* (Rossmassler, 1839) is kept separate from *P muscorum* (L., 1758). The systematic order used in the book is based on the results of a 1992 symposium on the systematics and nomenclature of north and mid- European land and freshwater molluscs organised by the Deutsche Malakozoologische Gesellschaft, and differs from that in Kerney l999.

There are bound to be areas of taxonomic uncertainty and uneven mapping coverage in describing the malacofauna of this area and readers are carefully warned (in section 11) that much work remains on such area as the systematics and anatomy of *Trichia* species, and many of the slugs, and on the faunas of high altitude lakes. Looking at the maps on page 355 it is not clear whether the records for *Helicella itala* (L., 1758) and *Xerolenta obvia* (Menke, 1828) are based on dissection; their ranges appear to overlap except in the south east.

Readers familiar with the British and Irish distributions will encounter some interesting differences in relation to species we consider common here. For example, *Lauria cylindracea* (da Costa,1778) is a rare species of west Switzerland; *Vitrea contracta* (Westerlund, 1871) is much less common than *V. crystallina* (Muller 1774); there is only one literature and one pre-1951 record for *Limacus flavus* (L.,1758); *Arion intermedius* (Normand,1852) is recorded only from scattered localities in north Switzerland (incidentally the colour photograph on p. 442 looks like the juvenile of another *Arion* species, and lacks the typical upstanding tubercles), and *Trichia striolata* is only recorded from a small area in the north east of Switzerland.

Most but not all the sections of the book have the text in two columns for German and French, but in the copy seen by the reviewers the text accompanying the maps is in German,and so are the sections on temporary introductions and greenhouse aliens, the doubtfully recorded species, uncertain records, and on the Pleistocene and Postglacial fossils not found living in the area. Section 11, the summary of the contents and results which also deals with unresolved problems, is in German, French, Italian and English.

The book is very well produced, with a slightly loose hard-back binding which enables it to lie flat. Photographic and map quality is generally excellent though caution is called for in attempting to identify *Pisidium* species from the photographs alone. The price is reasonable for a work of this type.

It is very strongly recommended as a landmark source of information on the molluscan fauna of the area. The authors are to be congratulated for all their hard work and persistence in seeing through this work.

[1] KERNEY M.P. 1999 *Atlas of the Land and Freshwater Molluscs of Britain and Ireland* Harley Books.

Barry Colville & David Long

*Recent Xenophoridae* by Kurt Kreipl and Axel Alf 1999 ConchBooks (Mainzer Str. 25, D-55546 Hackenheim, Germany) 148pp. ISBN 3-925919-26-0. Price 115 DM Hardback.

*Carrier* "Shells have long fascinated scientists and laymen alike with their habit of fixing foreign objects - shells, pebbles or coral etc. to the surface of their own shells. This book gives a welcome popular coverage to the living members of the family."

After acknowledgements and introduction, the book continues with a general discussion of the Xenophoridae. This includes an overview of the various hypotheses which have been used to explain why *Xenophora* add foreign bodies to their shells -visual camouflage (the usually accepted reason), olfactory camouflage, tactile camouflage, to prevent the shell sinking in soft sediments, to increase the strength and/or size of the shell, to improve the shell's stability in strong water currents or to provide a safe feeding area for the living Mollusc. All these are discussed in one of the clearest accounts which I have read. I would personally have liked to have had some more information included on the living Xenophoras, habitat preference and feeding preference are only mentioned in passing, and there is no description/illustration of a living animal. While I realise that little is known of this aspect of the Xenophoridae to have covered this in greater detail would have been useful and might have encouraged field collectors to add to our current scanty information.

There follows a key to identify recent species first to generic then to specific level. Having tried this with a number of specimens I have found it to work well, provided that one has at least basic locality data for the specimens - seven of the nineteen steps in the key are of geographic separation - since as the authors say "Species in the genus Xenophora are highly variable in almost all of their shell characteristics. Consequently, many species cannot reliably be identified by a single morphological feature; rather, sets of such features have to be used. However, some species have well-defined geographic ranges so that information on the locality in most cases will allow successful species identification." For non English speakers this identification key is helpfully repeated in German, French and Italian.

The bulk of the book consists of a systematic account of the 26 living species/subspecies considered valid. Information for each species includes; data on type specimens, type localities and range of the species. Together with descriptions covering the height of the shell, diameter of the base, angle of the spire, colour and sculpture of both the dorsum and base, the shape of the base, size of the umbilicus, and extent of attached objects. Additional comparisons with similar species help to emphasise differentiating characteristics.For each species a detailed synonomy is given with full page references for valid taxa and abbreviated references – author and date only – for synonyms. Interspersed with this text are some 20 illustrations reproduced from 'classic' shell books of the past, some of these illustrations being from the original descriptions of the species - together with some 44 black and white photographs, many showing enlarged details of the basal sculpture. Overall the text is both clear and concise, although the inclusion of a short glossary might have been helpful for the ordinary collector, where terms like opisthocline and prosocline are used. The text is relatively free of errors - on p. 67 Hamley should read Hanley, and the date of publication for Buonanni's "Ricreatione dell' occhio e della mente . ." should be 1681 not 1841, while on p. 56 the subgenus Austrophora is misprinted as Austroharpa, I would have expected this to have been picked up on proof reading given that the two authors helped describe this subgenus.

Twenty-eight full colour plates clearly illustrate each species from dorsal and ventral perspective and in profile, while by illustrating several specimens for each species the authors help to show the variability within the species. The quality of the colour plates is excellent although in one or two instances the lighting used has affected the colour tone, for example in two views of the same specimen of *Xenophora japonica* in one picture the shell appears white and in the other yellow.

Other sections of the book include a listing of Xenophoridae by geographical distributions, a list of recent taxa and an index of valid taxa. Finally there is a six page Bibliography, and it is unfortunate that this should let down the otherwise high standard of the book. For example in the discussion of the collecting habits of Xenophoridae references are made to eleven works, of these seven cannot be found in the Bibliography. Most surprising is the inexcusable omission of W. Ponder's "Xenophoridae of the World" *(Australian Museum Memoir* **17**: 1983) which was the first comprehensive revision of the family for some 100 years; the authors frequently refer to Dr Ponder's work throughout their text and moreover Dr Ponder provided the foreword to their work.

This book can be recommended to anyone interested in this fascinating group, and will make their identification much easier in the future.

Kevin J.T. Brown

*The Wentletrap Book : A Guide to the Recent Epitoniidae of the World* by Art Weil, Leonard Brown & Bruce Neville 1999 Published Evolver srl. (Via C. Federici, 1 -00147 Rome, Italy) 244pp. ISBN 88-8299-002-8. A4 Hardback. 220,000 Lira (Approx. £75).

The Epitoniidae, although including some of the World's most elegant shells, has long been a neglected family. A few of the larger species are illustrated time and again in popular shell books - there is probably no general book on tropical shells which does not illustrate *Epitonium scalare* - yet the vast majority of the nearly 600 smaller species have been largely overlooked. There have been few even regional monographs and certainly no worldwide overview of the family, so this volume is very welcome and goes a long way to redress the balance and place the Wentletraps firmly on the conchological map.

The authors have included details of some 565 species with truly worldwide coverage including species from polar and tropical regions, shallow and deep water (15,300 feet in one case). For each species a clear, concise, description is given emphasising those features most useful in identification - usually features of shell structure/sculpture; including size of shell, number of costae and varices, details of basal ridge and umbilicus, details of protoconch where known. Details of the distribution of each species are also given, although the authors acknowledge that distribution patterns are poorly known for many species, and that new records are constantly changing the known picture.

The species accounts are divided into eight broad chapters dealing respectively with the Epitoniidae of the Western Atlantic, the Eastern Atlantic and Mediterranean Sea, South Africa and Mozambique, the North West Indian Ocean and Red Sea, the Indo-Pacific, Japan, Australia and New Zealand, and finally the Eastern Pacific. Within each regional section the species are arranged alphabetically by genera, and alphabetically within each genus. This geographic arrangement is convenient for a field collector or anyone studying a particular regional fauna, but, to my mind, has a number of drawbacks. Many species have distribution patterns which overlap several of these broad regions. To give a couple of examples. *Boreoscala greenlandica* (Perry, 1811) "Occurs in the North Atlantic only as far south as Long Island but is quite common off Norway, Iceland and Greenland It also occurs off Alaska in the Pacific Ocean making it circumpolar." Similarly *Opalia crassilabrum* (Sowerby, 1844) "Ranges from the Philippines and the Red Sea to Natal, South Africa" Each of these species could have been placed in three of the Authors' regions. Thus to positively identify a species it may be necessary to refer to several of the regional chapters, and it is unfortunate that the regional accounts do not end with a list of additional species covered in other sections which also occur in the region.

*Epitonium couturieri* (de Boury, 1912) highlights a different problem "Because this species was described based on a specimen from an unknown habitat, we are uncertain whether it should form part of the Indo-Pacific fauna and are placing it in this chapter with much uncertainty".

Another difficulty with the geographic arrangement is the separation of closely related species. Under the Western Atlantic, *Narrimania azelotes* (Dall, 1927) we are told "This species is rather similar to *N. concinna* from the Eastern Atlantic. While there are differences, it is not clear whether there are two species or a single variable one". Yet *Narrimania concinna* (Sykes, 1925) appearing some 20 pages later in the Eastern Atlantic section has no cross reference to *N. azelotes*, which is particularly annoying as, of the two, only *N. azelotes* is illustrated.

The descriptions are accompanied by 507 illustrations, mostly photographs but including a few drawings, depicting some 494 of the species covered. The illustrations are conveniently placed opposite the text relating to each species. Inevitably, given the large number of photographs and the small size of many of the specimens illustrated - down to 1.7 mm, there are a few pictures which are a little fuzzy. The vast majority of the photographs are, however, of excellent quality. Moreover nearly 150 of the shells illustrated are type specimens enormously increasing the scientific value of the book. For each specimen illustrated, as well as species name, locality data and the size of the specimen is given. This is helpful given the varying magnifications used for illustrations on the same page. Museum references are also given for the type specimens.

The authors have included brief notes on Epitoniid biology, with references to more detailed studies, some very helpful notes on identifying Epitoniidae emphasising which features are most useful to distinguish species, and a very useful description of the many genera and subgenera within the family which clearly gives diagnostic features for each genus/subgenus - in *Opalia* for example shells are "characterised by the presence of microscopic spiral pits on the surface of the shell....". it also gives type species for each genus. The bibliography at six pages may seem short for a book covering a family of this size, but this probably reflects the general lack of previous study of the group. The bibliography is also largely restricted to 20th century publications.

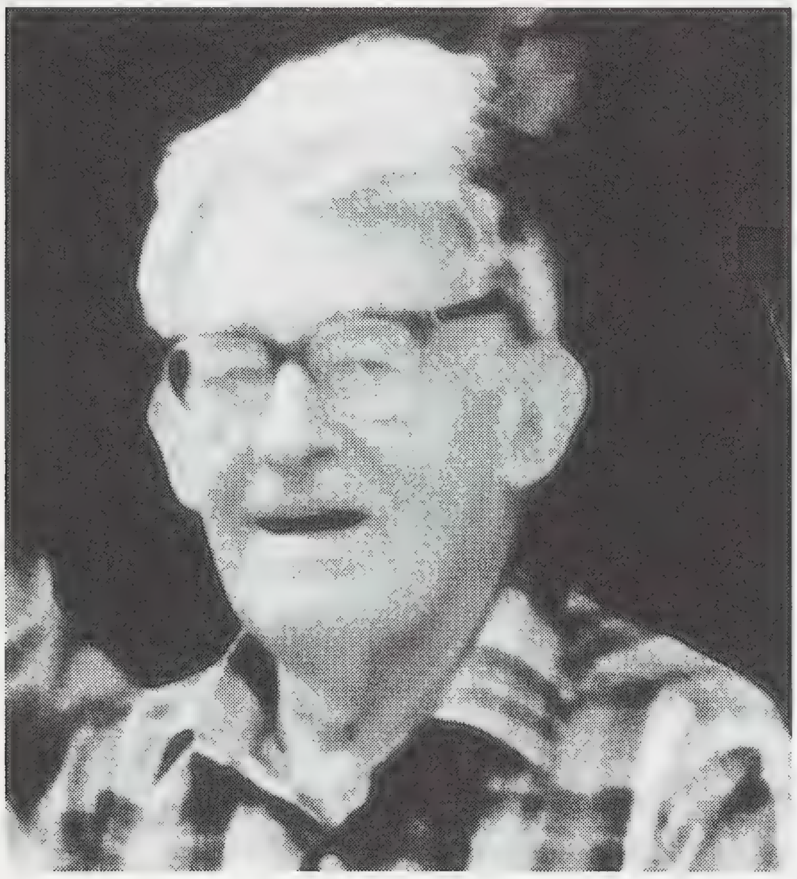
A large section of the book - some 34 pages - is devoted to a list of "Authors in Epitoniidae", in which is listed details of nearly 1,100 taxa proposed within the family. For each species information given includes author and date of description, current generic placement, size of the species, distribution of the species and whether the species is considered valid or should be rewarded as a synonym of another species. This list is presented in an innovative format, being arranged alphabetically by author. The index is comprehensive for both species and genera references so that although the book is arranged geographically rather than strictly taxonomically, it is easy to extract details of for example the species in a particular genus, or the many synonyms of *Gyroscala lamel-*

*losa* (Lamarck, 1822).

The authors have synthesised an enormous amount of information and presented it in a clear and readily accessible format, although our current knowledge of the family is constantly undergoing change, reflecting previous lack of study, this volume undoubtedly presents a base line for future workers to build upon. It will be a standard reference for both professional scientists and amateur collector for many years to come.

Kevin Brown

# TERENCE ELDON CROWLEY 1915-1999: OBITUARY, BIBLIOGRAPHY AND NEW MOLLUSCAN NAMES



Terence (Terry) was born in Otley, Yorkshire on the 12th July 1915. He was educated at Bradford Grammar School and Leeds University, graduating in 1937 with a B.Sc in Engineering. After graduating, he was frequently employed by the Ministry of Defence throughout his life. While he was with them he was one of the first people to learn American 'time study' which was improved and became 'method study'.

During the 2nd World War Terry spent some of his time in London. During the course of the buzz bomb raids, he developed the idea of the Bonus Scheme for rewarding workers who did an exceptional job. In Terry's case this was getting temporary and permanent prefabricated buildings put up very quickly to accomodate homeless people. He went into partnership with R.H. James and Partners to prepare bespoke Bonus Schemes but it was wound up in 1956. Terry rejoined the Ministry of Defence and worked at Denham for a few years. He was seconded to the US Air Force at Brize Norton as a civilian engineer. In 1964 Brize Norton was handed back to the Royal Air Force and Terry was then employed at Upper Heyford until he retired in 1975 at the age of 60.

On retirement Terry learned china mending from an expert and was much in demand, turning his hand to other things too. He assisted at Woodstock Museum including being woodlice recorder for several years. This was in addition to his extensive array of non-molluscan interests, the most important of which was motor bikes. He was interested in fossils, coins, weapons, clay pipes, beam engines, church architecture, stately homes, D. H. Lawrence, railways, and musical boxes and ran the Bampton Sunday School with his wife Wendy. He wrote four books for the Shire Publications: *Discovering Old Motorcycles* (1973, 1977, 1978, 1981); *Discovering Old Bicycles* (1978, 1981); *Discovering Mechanical Music* (1975, 1977) and *Beam Engines* (1976, 1978, 1982, 1986). Terry wrote a more scholarly book on beam engines, *Beam Engines: a massive chapter in the history of steam,* published by Oxford, Senecio Books,1982, which he was revising for a second edition when he died.

Terry married Miss Wendy Peake in 1939. They had first met on the Yorkshire coast in 1935 when Terry was on a student field course and Wendy was employed as a potter. Wendy was well known to Conchological Society members for her warm hospitality at Bampton and organising teas at the Society meetings. Wendy was an extremely talented artist, as befitted a Peake. She excelled at terracotta models of people. Wendy and Terry had one daughter, Linnet.

Terry joined the Conchological Society in 1951 at the instigation of Guy Wilkins. He was elected to the Council in 1955 and served the Society as Honorary Secretary from 1960–1970, covering meetings, general enquiries and membership matters. He was appointed President in 1972–3, proposed by myself. He gave two presidential addesses (1973,1975). He was honoured by being elected president again for the centenary year of 1976 and was elected an Honorary Member in recognition of his services to the Society.

Terry's principal molluscan interest was in African land snails. He wrote reviews on the taxonomy of African Achatinids with T. Pain. These were published in the *Annals* of the Musee Royal d'Afrique Central, Tervuren, Belgium as most of the work was based upon their collections. Ordinary colonial civil servants were instructed to collect all sorts of specimens from their locale and send them to the museum. They have, in consequence, the largest collection of West African land snails in the world. Terry was an Honorary Research Associate for many years, making numerous trips to work there.

Terry had a trained and analytical mind and was able to identify and ennumerate the characters of the species in the group in question. This was an invaluable asset when confronted with masses of specimens that were acumulated to make the taxonomic work possible. He was a good draughtsman and an excellent technical writer. All species were based on shell and animal morphology, distribution and colour as neither allozyme electrophoresis or DNA fingerprinting were yet available. Opinions on the species and papers were sought from other land snail workers, principally the late Dr. Joseph Becquaert and Dr. Bernard Verdcourt. J. Bequart also looked at types in the Smithsonian Museum, Washington, D.C. and gave his opinion about their identity. Many duplicate specimens from the Musee Royal de l'Afrique Central were added to Terry's collection with permission from the curator. The large collection of land shells has been presented to Leeds Museum.

Terry Crowley was an amateur taxonomist who bought order out of the mares nest of species which was the legacy from the Victorians. He had a feeling for species and made good judgements about them. His work remains valid today.

We are grateful to Adrian Norris (Leeds Museum) for providing the following transcript of a short interview with Terry in January 1993:

> "I was always interested in natural history, even in the early days. My father fought in the East African campaign in the last war and he brought back a number of trophies of various kinds, which always interested me, including shells. These were not very good as specimens, as they had been picked up on the beach at places like Durban on his way into the interior. He also brought a number of *Pila ovata gordonii* from Lake Nyassa. In those days schistosomiasis was not understood of course, and the life history of the Bilharzia was still wrapped in mystery. As a doctor he felt perfectly sure that the intermediate host was a shell, and he picked on *Pila ovata gordonii,* incorrectly of course, as we know now, as the probable intermediate host. But his military duties, as a doctor, certainly didn't allow him to investigate in any detail. However, these shells came to me and when I evolved a child-like museum of my own at a very early age.
>
> [What age was that ?]
>
> "We lived in Harrogate, I must have been about 9 or 10, people used to give me odds and ends
>
> [You lived in Harrogate ?]
>
> "Yes I was born in Otley, and we moved when I was about 6, and my people lived there until after the war. The enthusiasm was then dormant then until about 1950, when I found myself in London. My home was then in Lancashire, but I was drafted, here and there on various jobs, and not able to get together, until some years afterwards. In 1950, I was in digs in London, and through a mutual friend, I met Guy Wilkins, who somewhere about that time was president of the Conchological Society, and he took me home, and his shell collection

was something of a revelation to me. Also the enthusiasm, which is well known Guy talked about, and he said well if you are marooned in London with nothing to do, why don't you join the Conchological Society, and he gave me a collection of shells, odds and ends, that he had around the place, beautiful specimens, but mostly without localities, and he sold me cheap, a number of books, including Chenu, which really set me off. I took his advice and I joined the society. He was then in an advertising firm, and he did a lot of artwork. He was a very fine artist, but later on of course, he joined the British Museum as a shell curator, and I was always welcome there."

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## CROWLEY NEW SPECIES

***altitudinaria, Archachatina (Tholachatina)*** Crowley & Pain 1961e: p. 151–152, fig. 7. Holotype:- Tervuren museum, 277868.

***arenaria, Achatina*** Crowley & Pain 1961e: p.139–141, fig. 1. As a new sub species of *Achatina bandeirana.* Holotype:- Tervuren museum, 185116. (Achatinidae)

***benoiti, Burtoa*** Crowley & Pain 1959b: p.22–24, plate II, fig. 8. As a new sub species of *Burtoa nilotica.* Holotype:- Tervuren museum.

***bequaerti, Archachatina (Tholachatina)*** Crowley & Pain 1961e: p.148–149, fig. 6. Holotype:- Museum comparative Zoology, Harvard.

***calcicola Achatina (Lissachatina)*** Crowley & Pain 1961e:144–146, fig. 4. Holotype:- 142968 Tervuren museum.

***congoensis, Burtoa*** Crowley & Pain 1959b: p. 27–28, plate II, fig. 9. As a new sub species of *Burtoa nilotica.* Holotype:- Tervuren museum 5072.

***cylindricus, Limicolariopsis*** Crowley & Pain, 1961c: p.16–17, Pl.1. figs.6, 7. Holotype:- Coryndon museum

***ecclesi, Neothauma*** Crowley, Pain & Woodward 1964e: p.19–20, plate II, figs 8–10. Holotype:- Tervuren museum, R.G.mall 793.221. (Viviparidae)

***elgonensis, Limicolariopsis*** Crowley & Pain,1961c: p.29–30, Pl.111, fig. 3. Holotype:- Corydon museum

***ellisi, Limicolariopsis*** Crowley & Pain 1964d: p.191–192, figs 5&6. Holotype:- Tervuren museum, 608889. (Achatinidae)

***insularis, Archachatina (Tholachatina)*** Crowley & Pain 1961e: p.149–151, fig. 7. Holotype:- Tervuren museum, 114917.

***laevis, Limicolariopsis*** Crowley & Pain, 1961c: p.28–29, Pl.111, figs 1, 2. Holotype:- Coryndon museum No.955.

***leakyi, Limicolaria*** Crowley & Pain, 1963 *Palaeontographica*, **121**. A.

***lomamiensis, Achatina (Pintoa)*** Crowley & Pain 1961e: p.147, fig. 5. Holotype:- Tervuren museum, 97115.

***mayumbensis, Achatina*** Crowley & Pain 1961e: p.141–142, fig. 2. As new sub species of *Achatina bandeirana*. Holotype:- Tervuren museum, 283366.

***mulanjensis, Achatina (Lissachatina)*** Crowley & Pain 1981: p. 954–957, plate VI, figs 1–4. Holotype:- Tervuren museum MRAC 800985.

***propinquus, Synapterpes (Promoussonius)*** Crowley 1956. Holotype:- National Museum & Gallery, Cardiff 1981.118.00190.

***simulans, Achatina*** Crowley & Pain 1961e: p.142–144, fig. 3. As new sub species of *Achatina schweinfurthi*. Holotype:- Tervuren museum, 302304.

***verdcourti, Burtoa*** Crowley & Pain 1959b: p.12–17, plate I, figs 1–2. As a new sub species of *Burtoa nilotica*. Holotype:- Coryndon museum, Nairobi.

***verdcourti, Limicolariopsis*** Crowley & Pain,1961c: p.26–28, pl. 11, fig. 9. Holotype:- Corydon museum.

# OBITUARY – ROGER FRESCO-CORBU

## (1912–1999)

Roger Fresco-Corbu was born in Constantinople on 22 July 1912, where his Father, Jules, a timber trader had gone with his wife, Hortense from Roumania, to work. Unfortunately this marriage didn't last and so at the start of the Great War, his mother moved back to Braila, Roumania where they all lived with Roger's grandparents. Roger's Mother met and married Jack Corbu who was British Vice-Consul in Bucharest and whom Roger always looked upon lovingly, as his Father. It is not surprising that his early life was spent in a multi-lingual environment, speaking Roumanian, French, German and English fluently and in later life also read widely in several other European languages.

He came to England in 1930 to study at Durham University, but it had to be Engineering according to his step-father's wishes. Not being happy with the course, he changed to Marine Engineering and gained a BSc from Armstrong College, for whom he rowed and played Rugby. During his time at Durham he also carried out work experience in the shipyards, but with the outbreak of war, having been naturalised a British subject in August 1939, he felt that it was right for him to volunteer into the RAF where he quickly moved up to the rank of Flight Lieutenant. He served in North Africa, taking part in the Battle of El Alamein and then worked his way up through Sicily and Italy along with spending some time on Malta. At the end of the war, due to his knowledge of languages, he worked for Military Intelligence in Germany investigating missing persons.

In October 1945, he married Joy, a WAAF Sergeant whom he met at Bletchley on one of his trips back to England. This lady, loved by all who knew her, encouraged and inspired Roger thereafter in all he undertook. Demobilised, he became a Naval Architect for Lloyds Register of Shipping in Fenchurch Street in London and chose to be London based rather than move around the overseas ports and re-locate his family from country to country. He was then able to spend his spare time on activities in many fields. To list his passions, let alone interests, would be too exhaustive for such a short note as this, but he was a member of the Sherlock Holmes Society, The Dickens Fellowship, The Geological Society, The RAF Association, The British Legion, The Button Society, The Conchological Society, The Matchbox Label Society and many other organisations too numerous to mention. He published many learned papers, articles and books on various antiquarian subjects, particularly in the field of tobacco associated material. Indeed, the collection of the latter that he and his wife assembled over 50 years grew to be the largest in private hands.

Overshadowing all these, however, was his enthusiasm for and profound knowledge of Conchology. A life-long member of the Society, he also sat on Council for some time. The writer of this tribute was fortunate enough to accompany him for most weekends over 8 years, on the 10Km census scheme. Together, we covered every square east of a line from The Wash to the Pevensey Levels, often setting off at 02.30 am to get a good day's work done.

These are mere dry facts. It is the personality of the man that makes him memorable. On the 17 June 1971, we found a living colony of *Ena montana* (Drap 1801) near Stowmarket in Suffolk. Roger's excitement was not so much in the fact of the find, but that, to quote him, "They're doing just what the book says - climbing trees!" It was his innocent and joyful approach to nature that made him an inspiration for the writer.

He had a sly sense of humour. Thirty years ago, I made a life-sized model of a slug, hid it amongst the flowers by his doorstep, and left him to find it. He said nothing to me for some months. Then, in comparing notes with him over his cabinets, I saw it, beautifully mounted in a plastic box. The label read, *Milax bluetackiensis.* Linnaeus was not credited. When Roger gave his huge molluscan collection to the Southend Museum in 1996, he kept only the fossils he had collected in Egypt in 1940, and the little blue slug.

The death of his wife in 1991, dealt him a blow from which he never recovered. Roger Fresco-Corbu belonged less to this century, than to the last, when Gentleman Scholars (and he was both of those) advanced the sciences by enthusiasm and love of the pursuit, rather than the narrow specialisation which prevails today. Such men as he deserve wider appreciation. It is to be hoped that some conchologist, reading this notice, will honour him by naming a new species *x x x Fresco-Corbui*. He would be delighted.

He left two daughters, Patricia and Marilyn. The former devoted many years of service to him, whilst raising a family, and it was at the home of the latter, in Spain, that he died peacefully on March 26 1999.

May he rest in peace.

Pat Mason

# INSTRUCTIONS FOR AUTHORS

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The Conchological Society endeavours to publish the *Journal of Conchology* in the most efficient and cost effective means possible while maintaining high standards of production. Consequently, from volume 36 onwards we have moved to maximise the use of electronic page make up.

Contributors are asked to follow these instructions closely. Failure to comply will cause delay and may lead to the return of the manuscript. All papers should be written in clear, concise English. Much material appropriate in doctoral theses is unacceptable for publication. Papers are considered on the understanding that their substance is not already published or offered for publication elsewhere.

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Taxonomic descriptions should follow the special instructions outlined below.

**NB The Journal will not accept descriptions of new species or subspecific taxa unless the primary type material is deposited in a public or institutional museum and carries a unique identity number. Descriptions of new taxa and taxonomic revisions must comply with the International Code of Zoological Nomenclature.**

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## Sequence for systematic descriptions in the *Journal of Conchology*

SUPERFAMILY }
FAMILY } As appropriate
SUBFAMILY }
Genus ***Semele*** Schumacher, 1817
Type species *Semele reticulata* Schumacher, 1817

*Definition* Text
*Comparisons* or *Remarks* Text

*Semele semele* Brown, 1890
(Reference to original description)
*Semele semele* Brown, 1890: 341, pl. 1, fig. 1
(References to subsequent citations and synonymy)
*Tellina vulgaris* Smith, 1910:23
*Semele semele* Brown- Jones 1940: 87
*Semele communis* non Green, 1915- Black 1950: 45
(Data on type material)
*Holotype* 1 sh, off Cape Beach, Cape County, Cape Country, 23°N33°E, 5m, ex. coll Brown, 23 xi 1997, Museum number 1950.12.12.
*Paratype* As Holotype
*Type locality* Text
*Material examined* Text

Authors are reminded that large quantities of data here may be curtailed and should therefore be summarised. Sequence of data should follow sequence given for holotype as appropriate. Live collected specimens as sp, complete dead shells as sh, single valves of bivalves as v, and fragments as fg.

*Measurements* Text

Except for type material measurements of other material examined should be summarised noting number of specimens measured, mean and range.

*Diagnosis* Text (If appropriate)
*Description* Text
*Derivation of name* *crassicosta* from the Latin *crassus*, thick and *costa*, rib; referring to the heavy radial ribs.
*Habitat* Text
*Geographic range* Text
*Comparisons* Text
*Remarks* Text

### REFERENCE STYLE

**Authors should note that the *Journal* is using full citations of journal titles**

References are listed alphabetically.

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OLIVER P.G. 1995 Bivalvia *In* S.P. Dance (ed) *Seashells of Eastern Arabia* 194–281 Motivate, Dubai.

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# Contents

## PAPERS

PAGE

HELLER J. & SIVAN N. A new species of *Melanopsis* from the Golan Heights, southern Levant (Gastropoda: Melanopsidae). 1

GOFAS S. Four species of the family Fasciolariidae (Gastropoda) from the North Atlantic seamounts. 7

OLIVER P.G. & ZUSCHIN M. Additions to the bivalve fauna of the Red Sea with descriptions of new species of Limopsidae, Tellinidae and Semelidae. 17

LA PERNA R. *Limopsis tenuis* Seguenza, 1876, a poorly known Mediterranean bivalve (Arcoidea: Limopsidae). 39

ARAUJO R. & RAMOS M.A. A critical revision of the historical distribution of the endangered *Margaritifera auricularia* (Spengler, 1782) (Mollusca: Margaritiferidae) based on museum specimens. 49

CIANFANELLI S., TALENTI E., BODON M. & MANGANELLI G. Two *Platyla* species from Sardinia (Gastropoda: Prosobranchia: Aciculidae). 61

KOZŁOWSKI J. & KOZŁOWSKA M. Weeds as a supplementary or alternative food for *Arion lusitanicus* Mabille (Gastropoda: Stylommatphora). 75

## COMMUNICATIONS

KILLEEN I.J. *Vertigo moulinsiana* in Kent. 81

TAYLOR J.D. & GLOVER E.A. Nomenclatural rectifications for Indo-Pacific Lucinidae. 82

DANSEY P. *Ensis minor* (Chenu, 1843) in Cardigan Bay. 83

REVIEWS 85

OBITUARY 93

INSTRUCTIONS TO AUTHORS 101

QL
401
Q15
MOLL

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# ECOLOGY AND LIFECYCLE OF *MYXAS GLUTINOSA* (MÜLLER) IN LAKES ON THE ÅLAND ISLANDS, SOUTHWESTERN FINLAND

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RALF CARLSSON[1]

*Abstract* Myxas glutinosa *was found in 4 lakes out of a total of 51 visited on the Åland Islands, Finland. The lakes are eutrophic with high values for water chemistry parameters and are rich in aquatic vegetation. A population of* M. glutinosa *in one of the lakes (Lake Bolstaholm) was monitored over two seasons. In spring, individuals live on rocks where they feed on epilithic algae and propagate, then die. In late summer the new generation hatches and is mainly found on leaves of water lilies. During this time they grow, feeding either on epiphytic algae or on decaying leaves. In late autumn, having reached their adult size, they descend to deeper water to hibernate.*

*Key words* Myxas glutinosa, *lifecycle, growth, Åland Islands*

## INTRODUCTION

The glutinous snail, *Myxas glutinosa* (Müller 1774) (also known as *Lymnaea glutinosa)* is a rare snail species that has been found sporadically in northern Europe during the last 50 years (Plate 1). Boycott (1936) mentions a few limited occurrences on the British Isles and Macan (1950) made a few findings in the English Lake District. Macan (1977) described the snail as rare. In the last few years it has been found in only two places in the British Isles. One of them is a pond near Oxford in the early 1990's (Walker *et al.*, 1991; Pond Action, 1992; 1993; Whitfield *et al.*, 1998). The other is Lake Bala/Llyn Tegid in Wales where it was recorded in 1998 (Willing & Holyoak 1998). In Finland it has been reported from several places during the 20th century. Luther (1901) regarded it as varying between common and rather common throughout the country with one site as far north as 69° N. Levanto (1940) found it in Lake Vesijärvi, Koli & Turkia (1964) in Lake Saimaa and Särkkä (1979) in Lake Päijänne. Aho (1966) found it in Lake Pyhäjärvi and some adjacent rivers in the vicinity of Tampere in southern Finland. Later he made a thorough analysis of Finnish snail communities (Aho, 1978a-c; Aho *et al.*, 1981). For the distribution in Sweden, where it is on the national red-list of threatened invertebrates, see von Proschwitz (1997). In Norway, the species is regarded as threatened and found in only three places (Økland & Økland, 1992; 1996). The species may be regarded as rare or threatened throughout its range. In Finland it seems to have a stronghold and was not considered an endangered species when the local government of the Åland Islands planned protection areas for the European Natura 2000 network (Jörgen Eriksson, pers. comm.). For a detailed report on the status of *M. glutinosa* in other European countries, see Whitfield *et al.* (1998).

The biology of the species is not well known, but it seems to prefer rocky or stony shores with scarce vegetation (von Proschwitz, 1997). One reason for overlooking the species may be that "the species breeds in early summer and then dies off so that only infants are present during the usual holiday season" (Boycott, 1936). The aims of this paper are to describe the sites where the species occurs on The Åland Islands and to describe the lifecycle of the species in one of the lakes. For conservational measures it is important to have an understanding of the ecology of the species in its natural environment.

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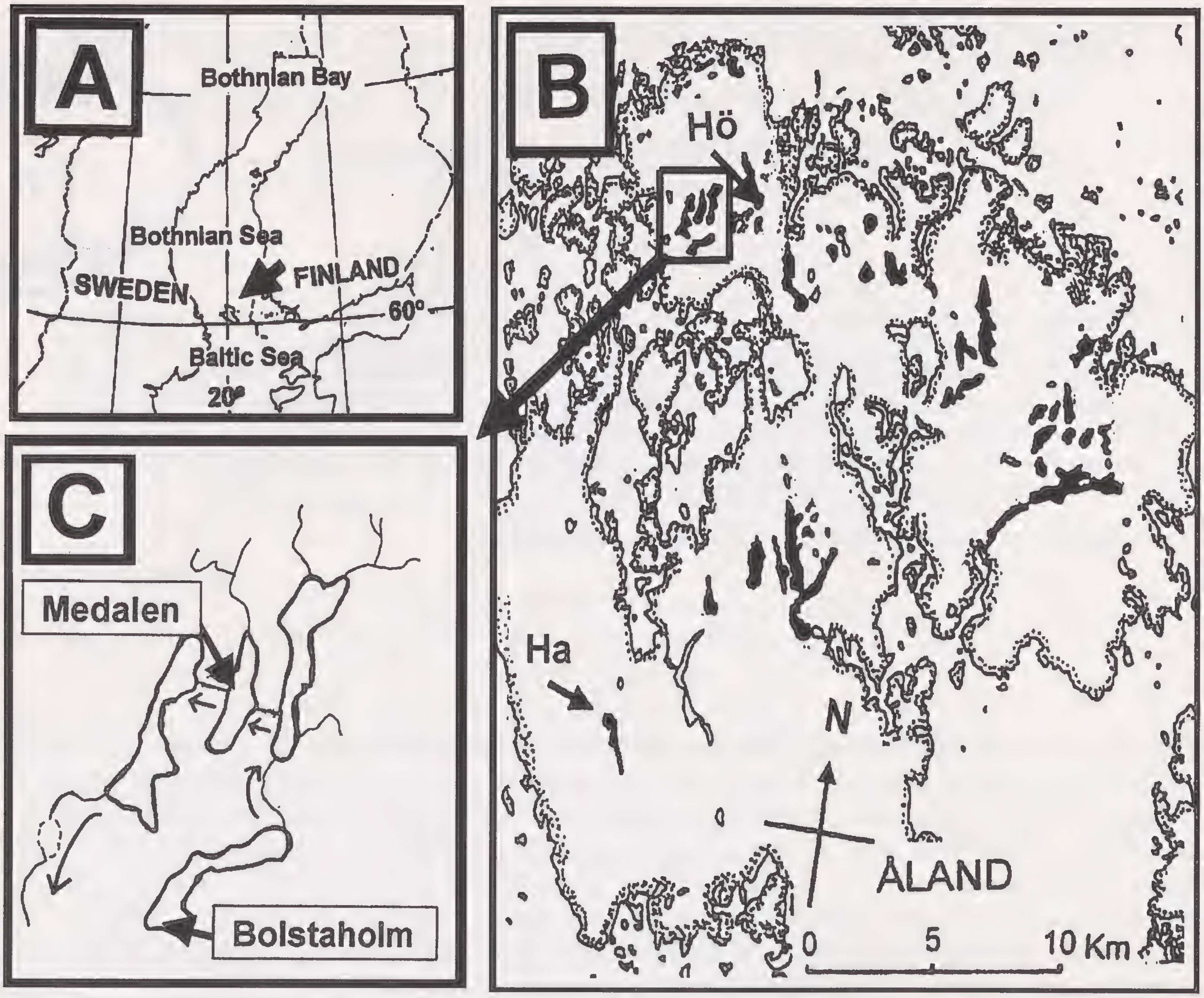

**Fig. 1** **A** The Åland Islands between Finland and Sweden. **B** Close-up with investigated lakes in black. *Myxas*-lakes indicated by arrows and initial letters of their names (Hö=Lake Höckböle, Ha=Lake Hammarlands Långträsk. Lake Bolstaholm area framed). **C** Close-up of Lake Bolstaholm-Lake Medalen system. The arrow at Lake Bolstaholm indicates the sampling location in the southwestern part of the lake.

## STUDY AREA

The Åland Islands, located in the southwestern part of Finland (Fig. 1) have a bedrock consisting of acidic rapakivi granites on the mainland and older acidic granites, gneisses and related rocks in the archipelago (Bergman, 1986). Despite this, the lakes on Åland are not acidic and poor in calcium as the soils covering the bedrock are rich in lime (Hausen, 1964). All the lakes surveyed in this study are located on the mainland Åland rapakivi massif which can be described as a gently sloping, dissected surface with higher hills in the northern and northeastern parts in the municipalities of Geta, Saltvik and Sund while the rest is mainly lowland.

The lakes on the Åland Islands are located at elevations ranging from sea level to 40.5 metres above sea level.

As for most of Scandinavia the Åland Islands have been subjected to a land uplift after the last ice age at a rate of approximately 40 centimetres per century (Lindholm, 1991). Consequently the lakes are of different ages as they were formed when bays were isolated from the sea during this uplift. The lakes in which *Myxas glutinosa* was recorded are briefly decribed as follows:

1. Lake Bolstaholm has a diverse catchment. Towards the south and southwest are high hills and the shores are rocks and cobble. The northern and northwestern shores are muddy with a gyttja sediment fringed by a reed belt. The lake bottom at one of the sampling sites used for lifecycle analysis is covered by a water moss, *Fontinalis* sp. Bounding the northern end of the lake is a large cattle farm, which has for many years discharged into the lake causing eutrophication.

2. The catchment of Lake Höckböle is heterogeneous. It is covered by mixed forests with cultivated fields and pastures mainly on the east side of the lake. A few summer houses are located at the shore. The shores are varied with rocks, sand and gravel and, in some places, marsh. The colour of the water is greyish green and so rich in calcium that precipitations can be seen on stones and submerged vegetation.

3. Lake Medalen is located in the same lake system as Lake Bolstaholm. This lake is shallow and extremely rich in vegetation. In summer there is relatively little open water as most of the surface is covered by plants. The lake is surrounded mainly by cultivated fields and the shores are fringed by a quagmire of reed beds *(Phragmites australis).* Only in one place is there a rocky shore, some 40 metres long.

4. Lake Hammarlands Långträsk is surrounded by rocky pine forests on the eastern shore and mixed forests on the western shore. To the south and north are cultivated fields. The average depth of the lake is 1.5 metres and the deepest point is 3 m. The western shore is rocky and the eastern largely road construction material as one of the main roads runs there. The southern and northern ends are very rich in vegetation and are undergoing a process of overgrowth.

## MATERIAL AND METHODS

Each lake was visited between 2 and 15 times during the period June-September 1994 to 1996 in order to record snails. In each lake one water sample was taken during one week in July 1994, and analyses were made on total hardness ($Ca^{2+}$ + $Mg^{2+}$) with a Hach (Loveland, Colorado, USA) test kit (EDTA titration), conductivity (Metrohm 660, Herisau, Switzerland), pH (Metrohm 691, Herisau, Switzerland) and water colour given as mg Pt/l with a Shimadzu UV 160A (Kyoto, Japan) spectrophotometer. Alkalinity was analysed by titration with 0.01 M HCI. Total phosphorus, total nitrogen, conductivity and salinity were analysed in two of the *M. glutinosa* lakes in October 1998. In addition values for elevations above sea level, lake surface areas, shore lengths and catchment areas were obtained from 1:20000 maps.

Snail collection was performed using a rod sieve (mesh size 1 mm), which was swept through the vegetation, and by hand picking from stones, branches and other hard objects down to a depth of about 1 m.

The collecting finished when no more species were found. Dominant plants, other invertebrates, fishes, birds and mammals were noted for each lake.

For lifecycle studies, Lake Bolstaholm (Plate 2) was visited during the ice-free season once a week from beginning of June 1998 till the new generation hatched in July 2000. On average, lakes are ice covered from the end of November to the beginning of April. In 1998 just one site on the lake was sampled but in September 1999 an additional site was investigated. On each occasion the sampling time was about half an hour (15 + 15 minutes). The shell length of individual snails was measured with vernier callipers (accuracy 0.5 mm) whereafter snails were released into the lake. Afternoon water temperature was recorded with a bath thermometer at a depth of 20 cm from August 1998. In addition, "day degrees" values (= heat sum = sum of daily average temperatures above 5 °C during the vegetation period) were obtained from The Agri- and

TABLE 1

Some topographical and water chemistry parameters in 4 lakes with *M. glutinosa* and in all investigated lakes for comparison. For all investigated means ± standard deviations are given.

| | **Lake Bolstaholm** | **Lake Höckböle** | **Lake Medalen** | **Lake Långträsk** | **All lakes (n=51)** |
|---|---|---|---|---|---|
| **Area,ha** | 33 | 6.5 | 16.5 | 56 | 33.2 ± 39.4 |
| **Shore length, km** | 3.6 | 1.4 | 2.3 | 7 | 3.6 ± 2.9 |
| **Drainage area, ha** | 1033 | 179 | 205 | 1240 | 647 ± 893 |
| **Elevation a. s. l., m** | 1.5 | 1.2 | 1.5 | 10.9 | 8 ± 9.4 |
| **Total hardness, °dH** | 6.2 | 9.6 | 5.5 | 8.4 | 3.72 ± 2.27 |
| **Conductivity, µS • cm$^{-1}$** | 230 | 260 | 210 | 345 | 160 ± 85 |
| **Alkalinity, meq • l$^{-1}$** | 1.51 | 2 | 1.09 | 1.4 | 0.87 ± 0.49 |
| **pH** | 8 | 8 | 7.3 | 7.7 | 7.6 ± 0.8 |
| **Water colour, mg Pt • 1$^{-1}$** | 45 | 60 | 50 | 65 | 55 ± 21 |
| **Total-P, • µg 1$^{-1}$** | 85 | 100 | ? | ? | ? |
| **Total-N, • µg 1$^{-1}$** | 880 | 1600 | ? | ? | ? |
| **Salinity (promille)** | 1.3 | 1.7 | ? | ? | ? |

TABLE 2

Plant species in the *Myxas*-lakes

| | **Lake Bolstaholm** | **Lake Höckböle** | **Lake Medalen** | **Lake Långträsk** |
|---|---|---|---|---|
| *Chara* sp. | | + | | + |
| *Equisetum fluviatile* | + | + | + | |
| *Hippuris vulgaris* | | | + | |
| *Nymphaea alba/candida* | | + | + | + |
| *Nuphar lutea* | + | + | + | + |
| *Ceratophyllum demersum* | + | | | + |
| *Ranunculus lingua* | | | | |
| *Ranunculus aquatilis* | | + | + | |
| *Cicuta virosa* | + | | | |
| *Utricularia* sp. | + | | + | |
| *Potamogeton natans* | + | + | | + |
| *Potamogeton praelongus* | | | | + |
| *Potamogeton perfoliatus* | + | + | | |
| *Potamogeton pectinatus* | + | + | | |
| *Potamogeton zizii* | | | | + |
| *Iris pseudocarus* | + | | + | |
| *Phragmites australis* | + | + | + | + |
| *Calla palustris* | + | | | |
| *Lemna trisulca* | + | | | |
| *Lemna minor* | | + | | |
| *Typha angustifolia* | | + | + | + |
| *Typha latifolia* | + | | | |
| *Schoenoplectus lacustris* | + | | + | + |
| *Eleocharis palustris* | + | | | |

Horticultural Research Station of the Åland Islands. For the purpose of analysis, individuals from the two sampling sites were treated as one population. Kruskal-Wallis one way analysis of variance (SYSTAT for Windows™, Version 5.05 by SPSS) was used for testing differences in length distribution between sampling occasions.

## RESULTS

Average values for water chemistry and topography for all 51 lakes investigated are given in Table 1 together with individual data for the four lakes in which *M. glutinosa* was found (called the *Myxas*-lakes from here on). The *Myxas*-lakes are eutrophic with a lush aquatic vegetation. Plants recorded in the lakes are listed in Table 2 and invertebrates in Table 3.

For more detailed information on all the investigated lakes, see Carlsson (in press, a) and for data on snail species composition in the lakes, see Carlsson (in press, b). The fish assemblages of the *Myxas*-lakes are not completely known (Table 4). In Lake Höckböle only a few species are present (Gunnar Mörn, pers. comm.). Lake Bolstaholm and Lake Medalen possibly have the same species as two neighbouring lakes, described by Storberg (1981), which are connected to these lakes. The muskrat *(Ondatra zibethica)* was introduced into the Åland Islands in the 1920s and is present in the *Myxas*-lakes and in most other Ålandian lakes. Birds seen regularly in the lakes are mute swan *(Cygnus olor)*, mallard *(Anas platyrhynchos)*, teal *(A. crecca)*, garganey *(A. querquedula)*, tufted duck *(Aythya fuligula)*, goldeneye *(Bucephala clangula)*, coot *(Fulica atra)* and common sandpiper *(Actitis hypoleucos)*. Whooper swan *(Cygnus cygnus)* breeds in Lake Hammarlands Långträsk and in Lake Bolstaholm. Black-throated diver *(Gavia arctica)* is present in Lake Bolstaholm. Accidental visitors are white tailed eagle *(Haliaetus albicilla)*, grey heron *(Ardea cinerea)*, terns *(Sterna* spp.) and gulls *(Larus* spp.).

In Lake Bolstaholm *Myxas glutinosa* was first recorded from about end of April (2000) to the middle of May (1999), when a small number of adult overwintering individuals appeared, mainly on rocks. The water temperature was about 10 °C on these occasions. In the first week of June the last individuals were found at a water temperature of 19.5 °C. In 1998 adults were still seen during the last week of June and in 2000 a very large individual (19 mm) was seen in the middle of June. Reproduction probably took place during these weeks of late spring to early summer, though was not recorded. During the

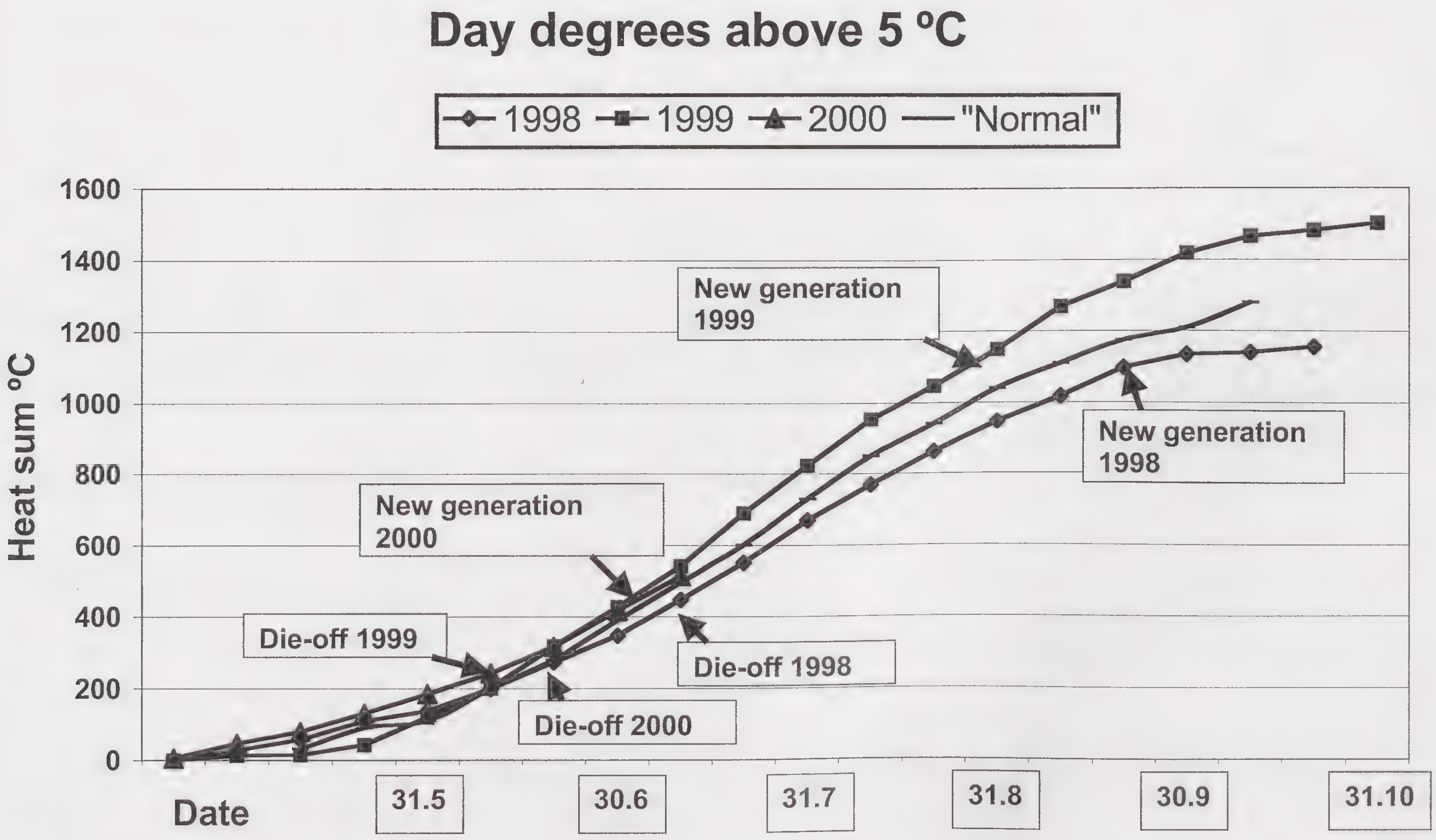

**Fig. 2** Day degrees of 1998, 1999, 2000 (until July 10) and average for the period 1961–1990 (= Normal). Events in the lifecycle of *Myxas* marked with arrows. The early appearance of the new generation in 2000 is due to finding the juveniles at an earlier stage of development.

TABLE 3

Invertebrate species/taxa in the *Myxas*-lakes. Note that this list is certainly incomplete for all other taxa but snails, as it is based on accidental field notes. Also note that *R. ovata* and *R. auricularia* are treated as one species, because an accurate identification is based on differences in internal genitalia.

| | **Lake Bolstaholm** | **Lake Höckböle** | **Lake Medalen** | **Lake Långträsk** |
|---|---|---|---|---|
| Hirudinea | | | | |
| *Piscicola geometra* L. | + | | | |
| *Erpobdella octaculata* L. | + | | + | + |
| *Theromyzon tessalatum* (Müll.) | + | | | |
| Crustacea | | | | |
| *Asellus aquaticus* (L.) | + | + | + | + |
| *Astacus astacus* (L ) | | + | | + |
| Odonata (Dragonflies) | + | + | + | + |
| Trichoptera (Caddisflies) | + | + | + | + |
| Ephemeroptera (Mayflies) | + | + | + | + |
| Mollusca | | | | |
| *Anodonta* sp. | + | + | + | |
| *Sphaeridae* spp. | + | + | + | + |
| *Lymnaea stagnalis* (L.) | + | + | + | + |
| *Radix ovata* (Drap.)/*R. auricularia* (L.) coil. | + | + | + | + |
| *Stagnicola palustris* (Müll.) | + | + | + | + |
| *Myxas glutinosa* (Müll.) | + | + | + | + |
| *Physa fontinalis* (L.) | + | + | + | + |
| *Planorbis planorbis* (L.) | | | | + |
| *Gyraulus albus* (Müll ) | + | + | + | + |
| *Armiger crista* (L.) | + | + | + | + |
| *Bathyomphalus contortus* (L.) | + | + | + | + |
| *Hippeutis complanatus* (L.) | + | | + | + |
| *Acroloxus lacustris* (L.) | | + | + | + |
| *Bithynia tentaculata* (L.) | + | + | + | |
| *Valvata cristata* Müll. | + | + | | |
| *Valvata piscinalis* Müll. | + | + | | |

TABLE 4

Fish in the Myxas-lakes. The species composition in Lake Bolstaholm and Lake Medalen is based on records from connected lakes (Storberg, 1981). In Lake Bolstaholm, records without brackets were made by the author. The records for Lake Långträsk are based on unpublished data (Karl-Erik Storberg, pers. comm.).

| | **Lake Bolstaholm** | **Lake Höckböle** | **Lake Medalen** | **Lake Långträsk** |
|---|---|---|---|---|
| Pike *(Esox lucius)* | + | + | + | + |
| Roach *(Rutilus rutilus)* | + | + | + | + |
| Rudd *(Scardinius erythrophtalamus)* | + | | + | |
| Tench *(Tinca tinca)* | | | | + |
| Bream *(Abramis brama)* | + | | + | + |
| White bream *(Blicca bjoerkna)* | (+) | | + | |
| Crucian carp *(Carassius carassius)* | | | | |
| Burbot *(Lota lota)* | (+) | | + | + |
| Perch *(Perca fluviatilis)* | + | + | + | + |
| Ruffe *(Acerina cernua)* | (+) | | + | + |
| Nine-spined stickleback *(Pungitius pungitius)* | (+) | | + | |

TABLE 5

Length distributions of *Myxas glutinosa* in Lake Bolstaholm on different sampling occasions. The individual marked with an asterisk was unreachable.

| **Date** | **n** | **x** | **σn-1** | **Range** |
|---|---|---|---|---|
| 19/9-98 | 16 | 8.4 | 1.5 | 6-10.5 |
| 25/9-98 | 16 | 7.7 | 1.8 | 5.5–11.5 |
| 3/10-98 | 24 | 9.0 | 1.8 | 5.5-12 |
| 9/10-98 | 11 | 8.3 | 1.5 | 5.5–10 |
| 18/10-98 | 12 | 9.2 | 1.6 | 6.5–11 |
| 23/10-98 | 3 | 9.5 | 0.9 | 8.5–10 |
| | | WINTER 1998–1999 | | |
| 13/5-99 | 4 | 14.1 | 1.5 | 12.5–16 |
| 20/5-99 | 3 | 14 | 1.00 | 13–15 |
| 27/5-99 | 6 | 12.6 | 1.7 | 11–15 |
| 3/6-99 | 8 | 13.3 | 1.4 | 11.5–15.5 |
| | | SUMMER 1999 | | |
| 29/8-99 | 2 | 11.5 | 0.7 | 11–12 |
| 6/9-99 | 5 | 8.6 | 3.9 | 3.5–12 |
| 15/9-99 | 17 | 9.6 | 3.2 | 4–14.5 |
| 21/9-99 | 26 | 9.7 | 2.6 | 4.5–12 |
| 29/9-99 | 31 | 9.7 | 2.9 | 3–13 |
| 5/10-99 | 40 | 9.4 | 2.9 | 4–13 |
| 12/10-99 | 30 | 9.9 | 3.1 | 4–13 |
| 19/10-99 | 14 | 10.7 | 2.6 | 6-13.5 |
| 26/10-99 | 53 | 9.8 | 2.6 | 4.5–14.5 |
| 3/11-99 | 43 | 9.9 | 2.5 | 3.5–15 |
| 9/11-99 | 58 | 10.1 | 3.0 | 3.5–15 |
| | | WINTER 1999–2000 | | |
| 25/4-00 | 3 | | Not measured | |
| 28/4-00 | 4 | 9.8 | 3.2 | 5–12 |
| 5/5-00 | 3 | 10.2 | 0.3 | 10-10.5 |
| 12/5-00 | 0 | | | |
| 23/5-00 | 0 | | | |
| 8/6-00 | 1 | 13-15* | | |
| 14/6-00 | 1 | 19 | | |
| | | SUMMER 2000 | | |
| 21/6 | | EGG CAPSULES UNDER BOULDERS | | |
| 4/7 | 2 | 2.8 | 0.4 | 2.5–3 |
| 11/7 | 2 | 8.5 | 3.5 | 6–11 |

hot and dry summer of 1999 the water level fell to 30–35 cm lower than normal.

In the middle of September (1998) and at the end of August (1999) the first juveniles of the year were seen on rocks from the surface down to a depth of about 0.5 m. The water temperature was about 18 °C (Fig. 2) when these juveniles were found and the effective temperature sum ("day degrees") 1090 °C (1998) and 1100 °C (1999). The average shell lengths of the juveniles were 8.41 mm (1998) and 8.6 mm (1999) respectively. However, the first two individuals recorded in August 1999 were 11 and 12 mm long. For the rest of the growth period, individuals of all sizes were recorded (Fig. 3 and Table 5). In 2000, with a more careful examination of the lake, egg capsules were found in the middle of June under cobble stones at depths around 30 cm. In the first week of July two juvenile individuals (2.5 and 3 mm) were seen under a submerged and decay-

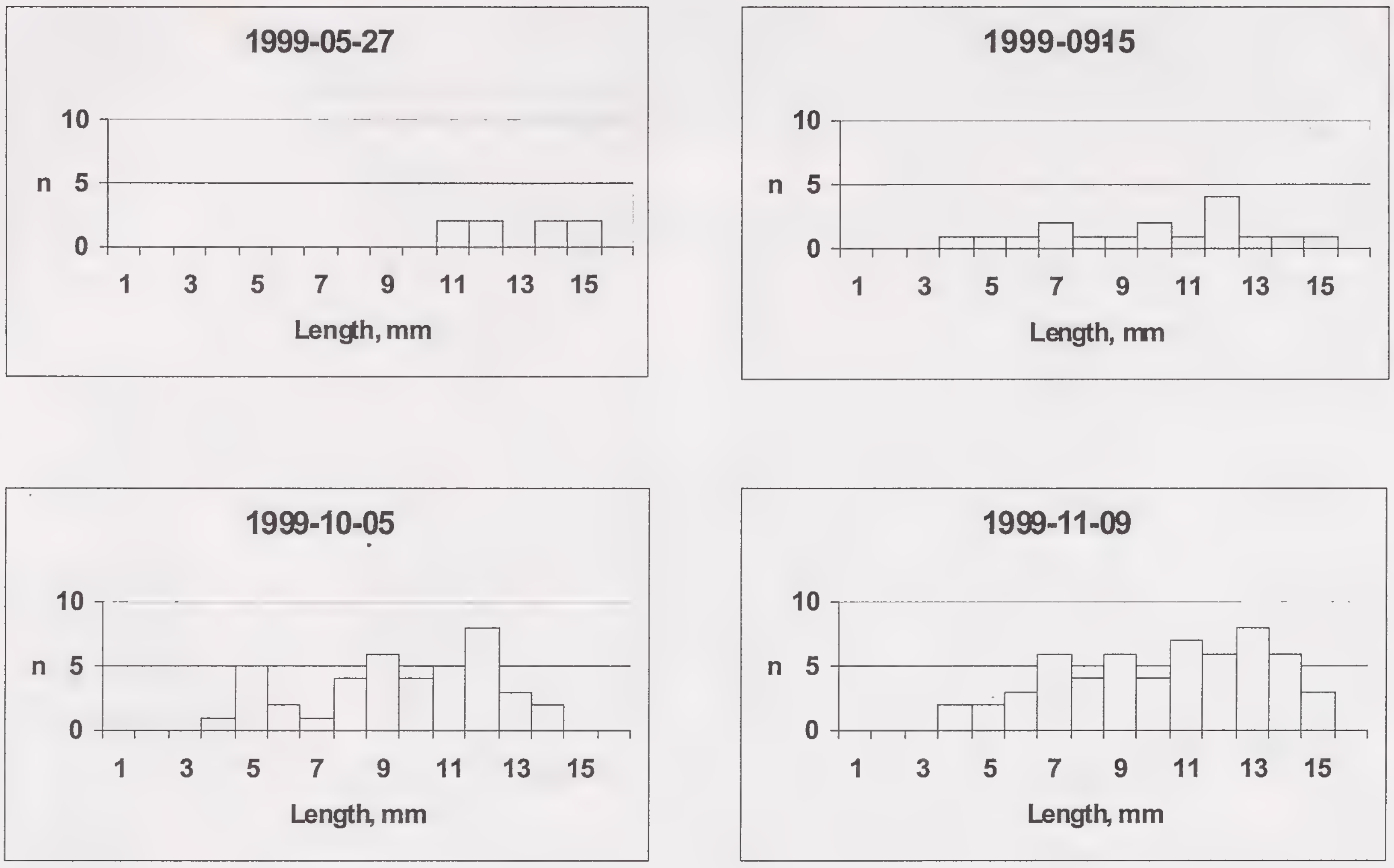

**Fig. 3** Length distribution diagrams for *Myxas glutinosa* in Lake Bolstaholm. Note the spring distribution with only adults present. From the other diagrams it is obvious that small juveniles occur frequently during all times of autumn and that there are most large adults late in the season.

ing snag. One week later individuals of 6 mm and 11 mm length were recorded. Length increase of the population could not be confirmed, as the size distribution between sampling occasions did not differ significantly.

When the new generation first appeared, it was mostly recorded from rocks. Later, in the autumn, they were more frequent on leaves and stalks of water lilies *(Nuphar lutea)*. The occurrence on plants was even more pronounced at the end of the season when the majority were recorded from submerged and well decayed water lily leaves (Plate 3). The highest number of snails recorded on a single leaf was nine. On November 9, 1999, many individuals were noted on decaying water lily plants in deeper water (> 0.5 m). They were inaccessible from the shore, but a visual indication was that hundreds were present. On the final occasion of 1999, November 18, the water temperature was 2.5 °C, after some nights with below-zero temperatures and there were no *Myxas* visible. By then the submerged water lily leaves had almost decayed completely and the water was extremely clear.

## DISCUSSION

*Myxas glutinosa* seems to be a species that prefers shallow locations with well developed submerged vegetation and hard water. This supports the findings of Boycott (1936) who considered it a hard water species. However, some of the lakes on the Finnish mainland, where the species has been found are extreme soft water lakes and Aho *et al.* (1981) refers to it as a soft water species. In accordance with this, Whitfield *et al.* (1998) claims that eutrophication is the most likely reason for the decline of the species in Europe. If so, the occurrence of *Myxas* in Lake Bolstaholm is an exception because this lake has received untreated wastes from a cattle farm for decades and shows moderate to high levels of nitrogen and phosphorus and may, according to Brönmark & Hansson (1998), be classified as a eutrophic lake. In Lake Höckböle the nitrogen and phosphorus values are even higher (Table 1). Furthermore, taking the other water chemistry parameters into consideration, it looks like *M. glutinosa* generally prefers high values for hardness, conductivity and alkalinity. The appearance of the species on (especially decaying) leaves of *N. lutea* is in accordance with Frömming (1956) who states that the species feeds on periphyton as well as on decaying plants (Plate 3). Could the appearance of the species on submerged leaves of water lilies, besides feeding, also be a kind of adaptation, reducing the energy needed to reach deeper water in late fall? Instead of spending energy on locomotion, they use the "water lily elevator".

Though there were no significant differences in shell length between single sampling occasions, there is an overall increase in average shell length from the appearance of the first individuals in late summer – early autumn to the disappearance in late autumn, when the snails descend to deeper waters for hibernation. The lack of significant differences may either be due to a small sample size or to the fact that reproduction within the population is asynchronous. Reproduction probably takes place as soon as, or before, individuals of the species are found in spring. This may be followed by an extended hatching period. For instance, very small (3.5 mm long) individuals were encountered as late as November. These individuals may not reach maturity before they descend to deep water. The first two specimens found in late summer 1999 cannot have reached their almost adult lengths of 11 and 12 mm in just over two months. The same applies to the 11 mm long individual recorded in July 2000. They may have hatched in late autumn 1998 and 1999 respectively. The reproduction of these "odd adults" probably takes place during this time, and the eggs hatch in late autumn. This pattern of reproduction continues year after year, leading to a seemingly staggered breeding cycle. Similar observations of parts of a population deviating from the usual lifecycle, have been recorded for other taxa. The amphipod *Monoporeia* (syn. *Pontoporeia) affinis* Lindström has a one year lifecycle in shallow areas and a two years lifecycle in deeper areas. In a meromictic bay, where the species should have a one year lifecycle, about 5% of the population was biannual because of local temperature conditions (Carlsson, 1983).

Growth seems to take place through winter and early spring, before the snails appear in the shallow waters of the lake (Table 2). Most of the egg-laying may take place on deeper bottoms or on shoots of water-lilies because few juvenile snails are seen before they have reached a length of about 8 mm in late summer. The lowered water level in 1999 is also an indication of this; eggs and embryos in shallower water would have dried out. Another reason for not finding smaller individuals may be that they spend the first part of their development on the underside of cobbles and boulders, where they are protected from predation. In Llyn Tegid they were recorded in that habitat (Willing & Holyoak, 1998).

In one case it seemed that mature individuals were copulating at the end of October; at least one pair of individuals were stuck to each other. If so, there appears to be no regularity in the lifecycle, other than a general pattern of egg-laying in late spring and hatching in late summer. In Poland, Feliksiak (1938) found that *Myxas* had two generations per year. This may be true also for the Åland Islands, or staggered breeding may occur within the whole population.

The water temperature may be a very important factor for the development of embryos. In 1998 which had a somewhat lower heat sum ("day degrees") than normal, the first individuals were found in early September. In 1999, which had a higher than normal heat sum, the first individuals were seen in late August. On both occasions the heat sum was approximately 1100 °C and the individuals were of about equal length. The day degrees used in this paper are based on air temperatures, but these strongly correlate with water temperatures (Økland & Økland, 1998). The physiological temperature needs of *Myxas glutinosa* are not known. Some species, eg. the crustacean *Asellus aquaticus* L., may require temperatures above 3 °C for their development (Økland &

Økland, 1998). Since the summer of 1999 included the warmest summer of the century (Ulla Boman, pers. comm.), it is possible that this temperature threshold for *Myxas* was frequently exceeded and the new generation appeared almost three weeks earlier in late summer than the previous year. In 1994, *Myxas* was also found in the middle of July (Lake Medalen) with a heat sum of only about 600 °C. In 1995 it was encountered in the beginning of August (Lake Höckböle and Lake Hammarlands Långträsk) with a heat sum of 750 °C. Whether these findings reflect a staggered breeding cycle or are a function of shallow lakes, where water heats faster than in wave-swept Lake Bolstaholm is hard to tell.

The occurrence of *M. glutinosa* on rocks in early summer may result from an undeveloped water vegetation this time of the year and the species feeding on epilithic algae. In autumn there is a gradual shift from rocks to *N. lutea,* where snails either feed on epiphytic algae or broken down leaf material.

As the water temperature drops down to about 4 °C (autumn overturn), the majority of snails move to deeper waters for hibernation. This was clearly shown between the last two sampling occasions in 1998 and 1999.

It is hard to draw any conclusions about competition or other biotic interactions from the species composition tables. It seems strange that *Myxas glutinosa* has not been found with the prosobranch gastropod *Theodoxus fluviatilis* (L.) in any investigated lake though this latter species is recorded from lakes which are interconnected with the *Myxas*-lakes. The reason for this is discussed elsewhere (Carlsson, 2000).

## CONCLUSIONS

In the Åland Islands *Myxas glutinosa* prefers lakes with a rich vegetation and high nutrient values. The lifecycle can be outlined as follows: Reproduction usually takes place in early spring and individual development takes the rest of the season and depends on the temperature of water. The development of juvenile snails is not synchronous and when they reach their full size, or when the water temperature is about 4 °C, snails descend to deeper areas of the lake for hibernation.

## ACKNOWLEDGEMENTS

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Photos: R. Carlsson

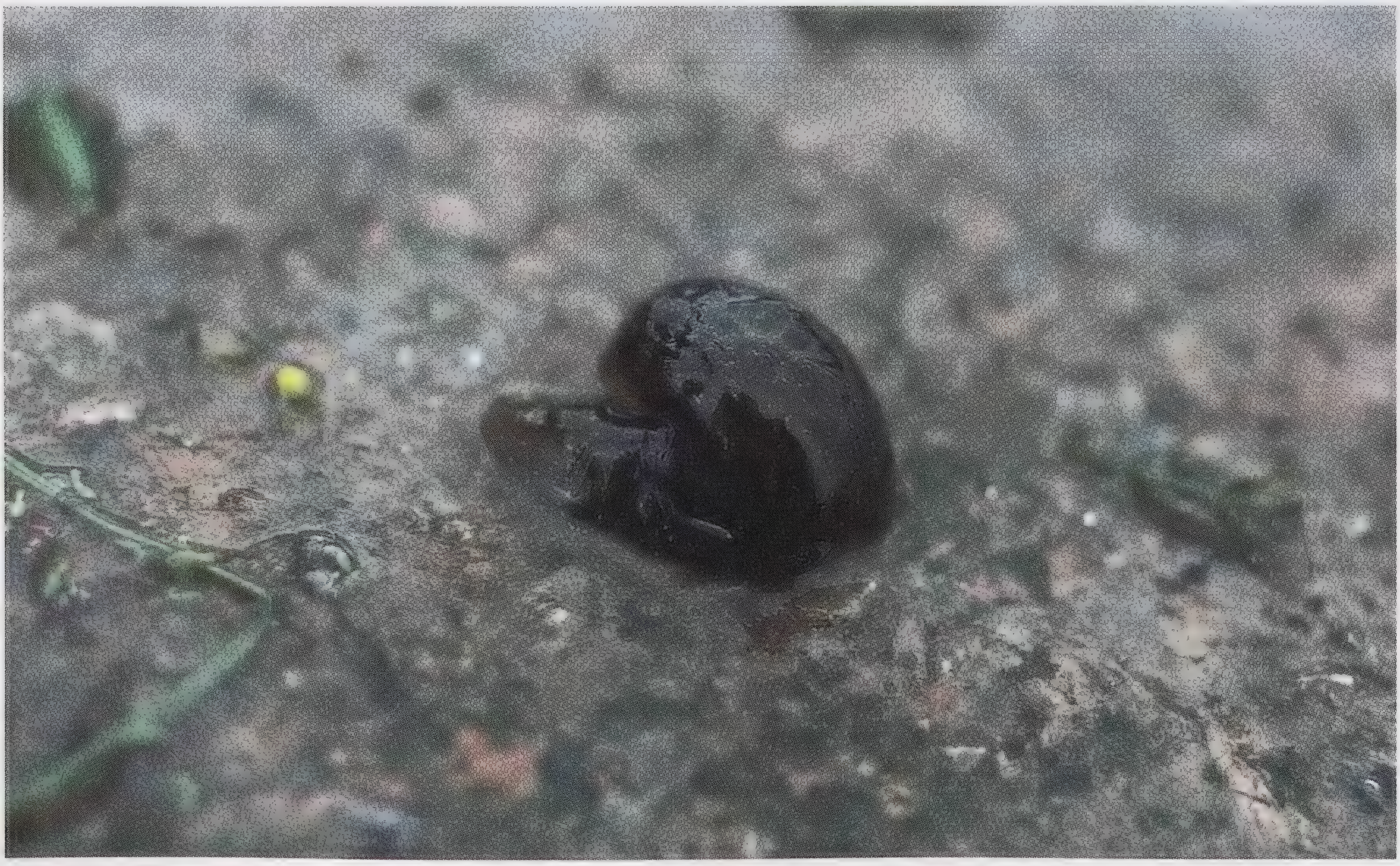

**Plate 1** The glutinous snail, *Myxas glutinosa*, is an endangered snail species in most of its current range. The individual on this picture was taken out of the water, but the habitat is still representative - bare rock.

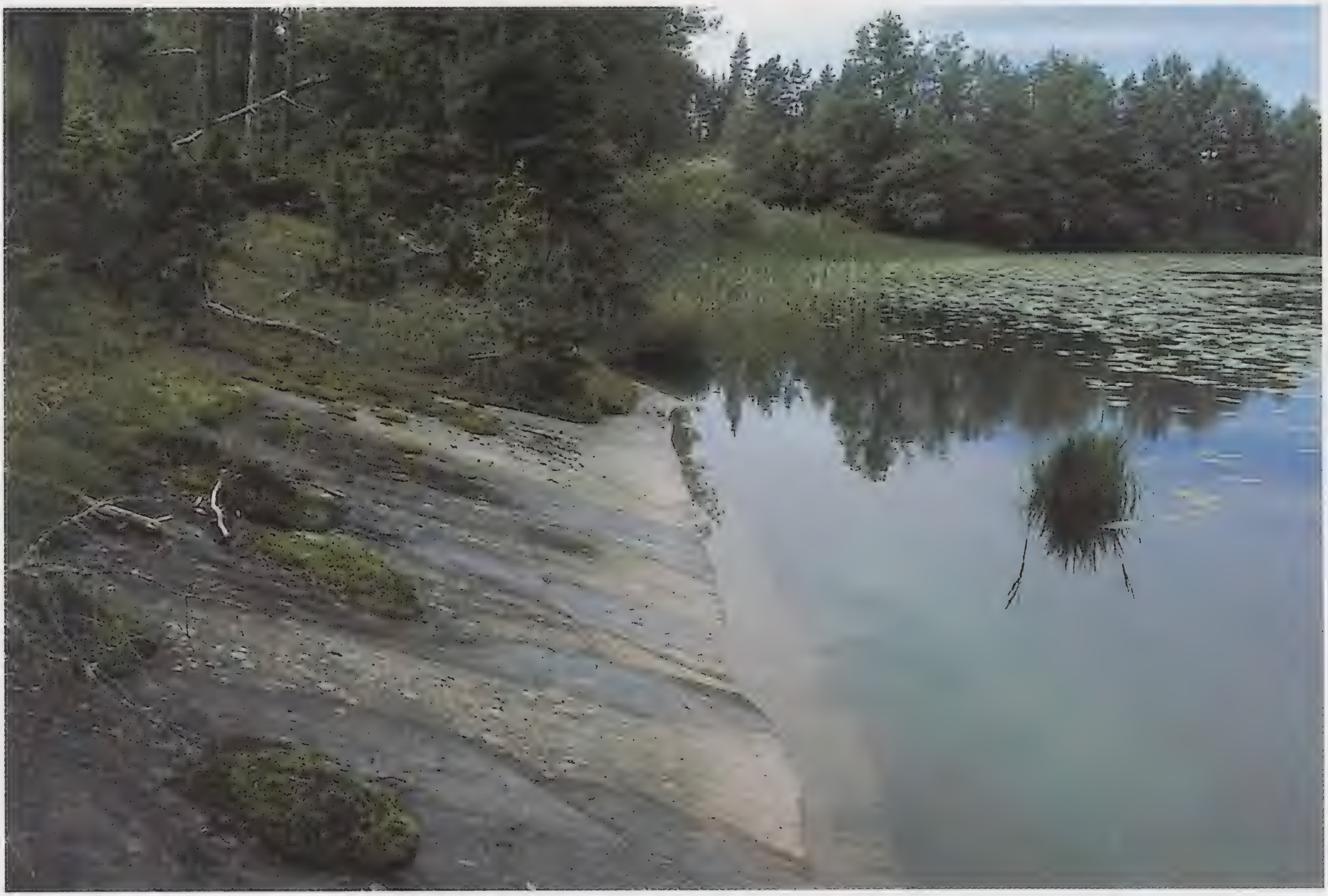

**Plate 2** The sampling site of Lake Bolstaholm. The sloping rocky shore is one of the main habitats of *Myxas* in spring. In late summer and autumn it is found in *N. lutea* stands in the background.

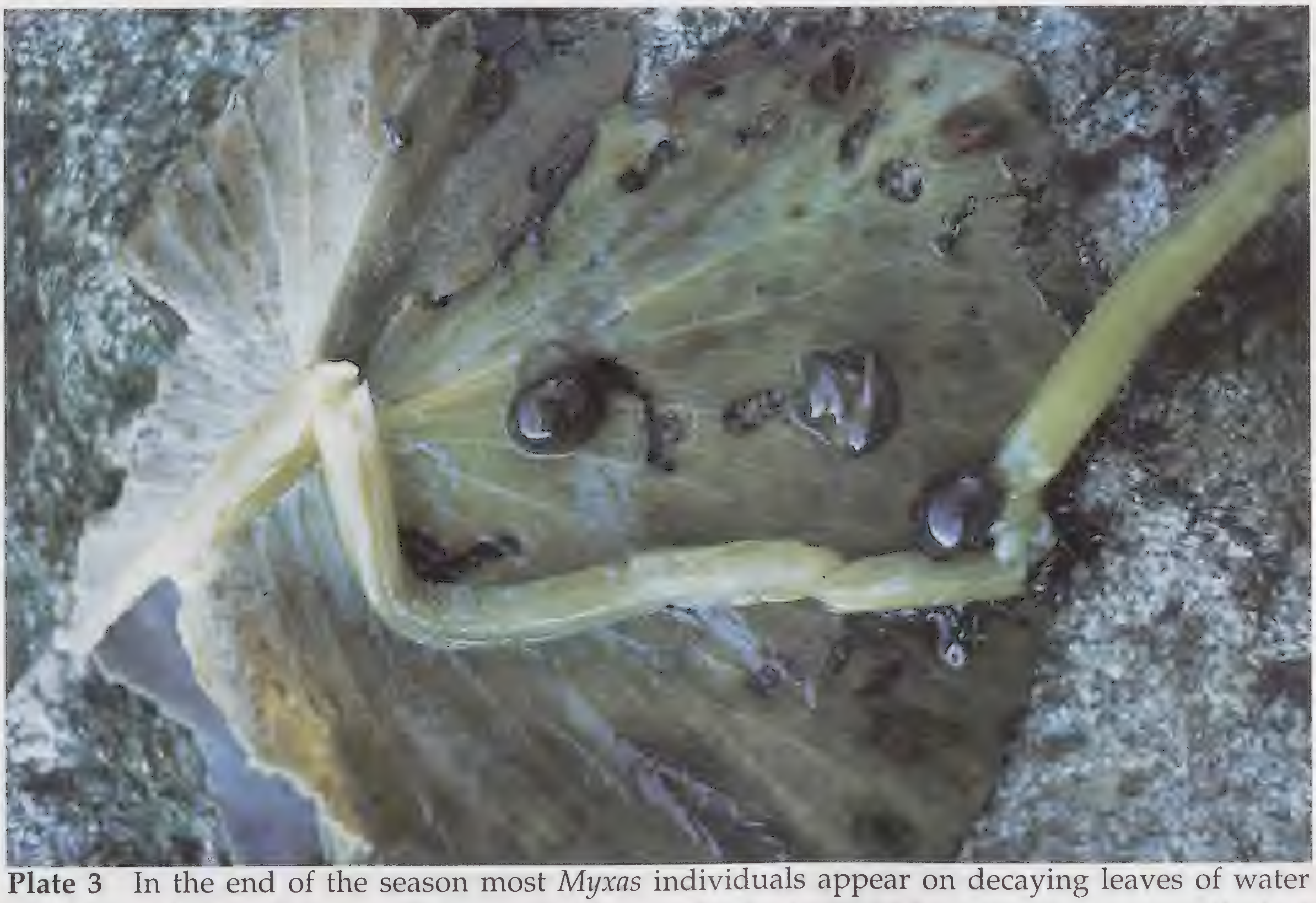

**Plate 3** In the end of the season most *Myxas* individuals appear on decaying leaves of water lilies. Note the size difference between the three individuals (12-13.5 mm) in the centre of the leaf and the small one (3.5mm) in upper left of the picture.

# OBSERVATIONS ON THE MORPHOLOGY AND ANATOMY OF *MARGARITINOPSIS DAHURICA* (MIDDENDORFF, 1850) (UNIONOIDA: MARGARITIFERIDAE)

DOUGLAS G. SMITH[1]

*Abstract Among the freshwater mussel family Margaritiferidae the Asian species are the least known. One of these,* Margaritinopsis dahurica, *occurs in the Amur River and Maritime province drainage systems of eastern Russia. A second taxon,* M. sujfunensis, *has been distinguished from* M. dahurica *on the basis of height/length ratio of the shell. The availability of several specimens assigned to these taxa has permitted a study of the shell and anatomy. Height/length ratios varied little within the sample and no clear pattern was discerned supporting a two species concept. Nevertheless, the shell characteristics of* M. dahurica *sensu lato clearly distinguish it from all other margaritiferid species. The anatomy of* M. dahurica *reveals that the species is correctly assigned to the Margaritiferidae.*

## INTRODUCTION

The freshwater mussel family Margaritiferidae is distributed discontinuously throughout the northern Hemisphere and the majority of species are restricted to continental margins. Among the described species, those occurring in east and southeast Asia are the least known or understood. Within the Amur River and Maritime region drainage systems of eastern Russia, two taxa have been described, *Margaritinopsis dahurica* (Middendorff, 1850) and *Margaritinopsis sujfunensis* (Moskvicheva, 1973). Both species were established on general characteristics of the adult shell only, the latter distinguished from the former essentially by height/length ratio. The taxonomic status of *M. sujfunensis* remains unsettled and while it continues to be treated as a separate species by some (Zatravkin and Bogatov, 1987), others regard it as a synonym of *M. dahurica* (Smith, 1980; Ziuganov *et al*. 1994).

Several specimens assigned to either of these taxa have been recently assembled and studied. This report presents the results of a study on characteristics of the shell and anatomy.

## MATERIALS AND METHODS

Specimens were assembled from private donors and museums. Abbreviations are UMA for University of Massachusetts at Amherst, NCSM for North Carolina State Museum, both in U.S.A., and ZISP for Zoological Institute, St. Petersburg (Russia). References used to check localities, where possible, were the Times Atlas of The World, Volume II, South-west Asia and Russia, Mid-Century Edition, 1959, and World Map - Russia - eastern part, by the American Map Corporation, Maspeth, N. Y., 1999.

The specimens are distributed as follows: Bureja River, near mouth of Ushman River, 1980, no other data, 1 shell, UMA MO.1872; Komissarovka River, Primorye Territory, 29 May 1993, 2 alcohol specimens, NCSM P4315; branch of Choz River, Cochlozkaya, 15 June 1974, 2 shells, ZISP n28; Belaja River, Habarovsk region, 6 May 1985, 2 alcohol specimens, ZISP n37; Suifin River (=Subutinca River?), "Primorsky" region, summer 1947, 1 shell (paratype, *M. sujfunensis*), ZISP n2; Argun River at confluence with Silka (=Schilka) River, presumably before 1850, no other data, 1 valve (paratype, *M. dahurica*), ZISP n75;

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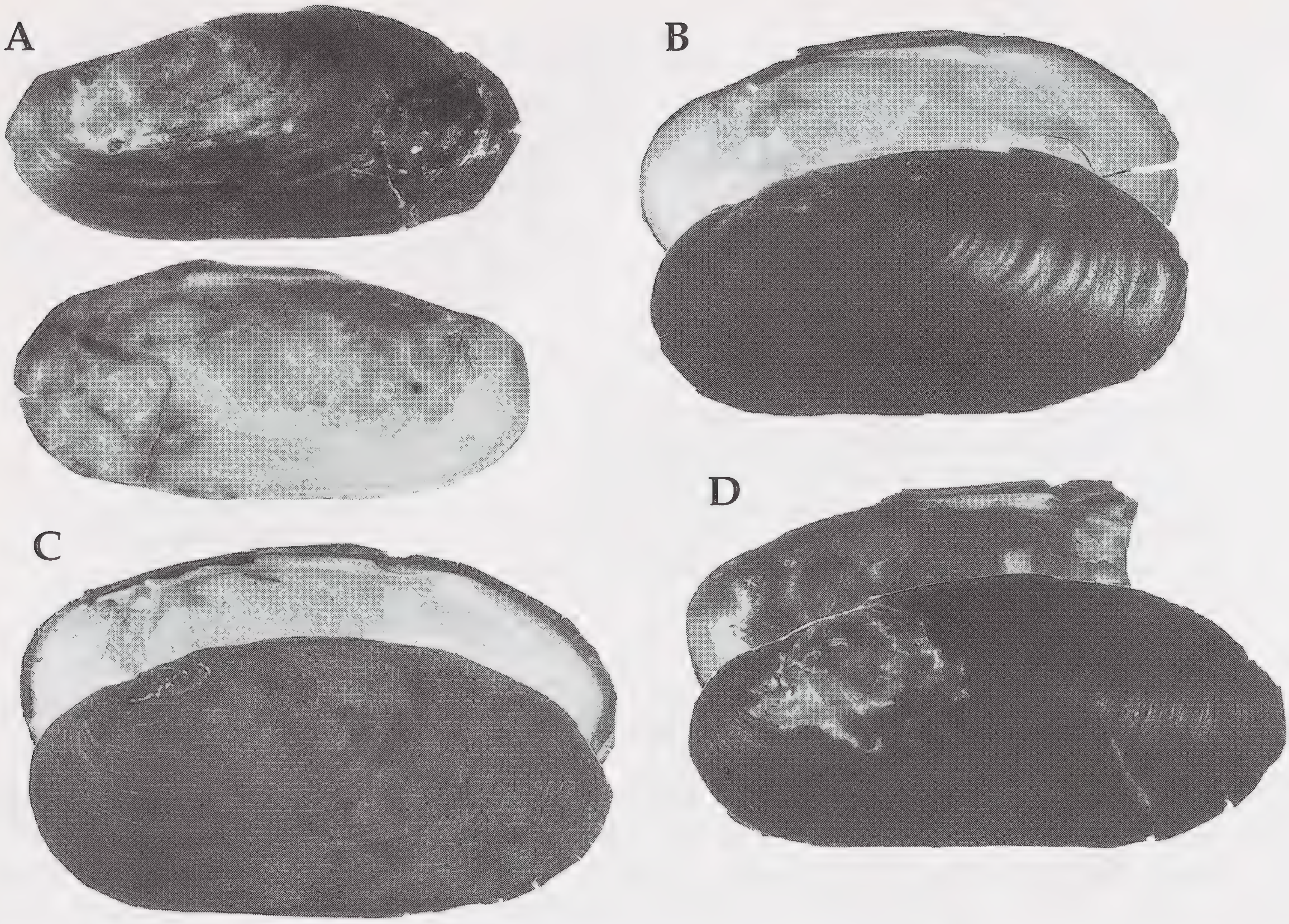


**Fig. 1** Shells of *Margaritinopsis dahurica* showing variation of form. **A** Paratype, 90 mm **B** Suifin River (paratype *M. sujfunensis*), 126 mm **C** Belaja River, 127 mm **D** Bureja River, 150 mm.

Komissarovka River, Barabas-Levada, 9 May 1998, 3 alcohol specimens, UMA MO.1881.

For histological inspection of the viscera, tissue plugs were removed using Miltex® biopsy punches, 4 and 6 mm. Elsewhere, small 1 cm$^2$ pieces were cut from the animal. Tissue samples were dehydrated in an alcohol series, cleared, and embedded in Paraplast®. Serial sections were cut at 4 or 7 µm intervals, mounted on slides, and stained with Harris' hematoxylin and counterstained with Putt's eosin. Seven specimens were sectioned. Dissections were performed with the aid of a Bausch and Lomb binocular stereo dissecting microscope mounted on an adjustable boom. Dissections were somewhat limited by the condition of the specimens. Specimens were in too poor condition to provide information on stomach anatomy. Photographs of sectioned tissues were taken with a Wild camera mounted on a Wild M20 bright field microscope.

Systematic arrangement of generic taxa follows Smith (in press).

## RESULTS

### SHELL

Species of the Margaritiferidae are comparatively large among unionoid bivalves and *M. dahurica* sensu lato is no exception (Fig. 1). The largest specimen examined was 150 mm shell length and several others exceeded 120 mm. The shell is compressed and the valves are very thin, almost fragile. Anteriorly, the shell is slightly thickened, the nacre of the thickest part occasionally exhibiting a light salmon color. Elsewhere, the nacre is white to a light iridescent blue. Mantle attachment scars are variable in representation,

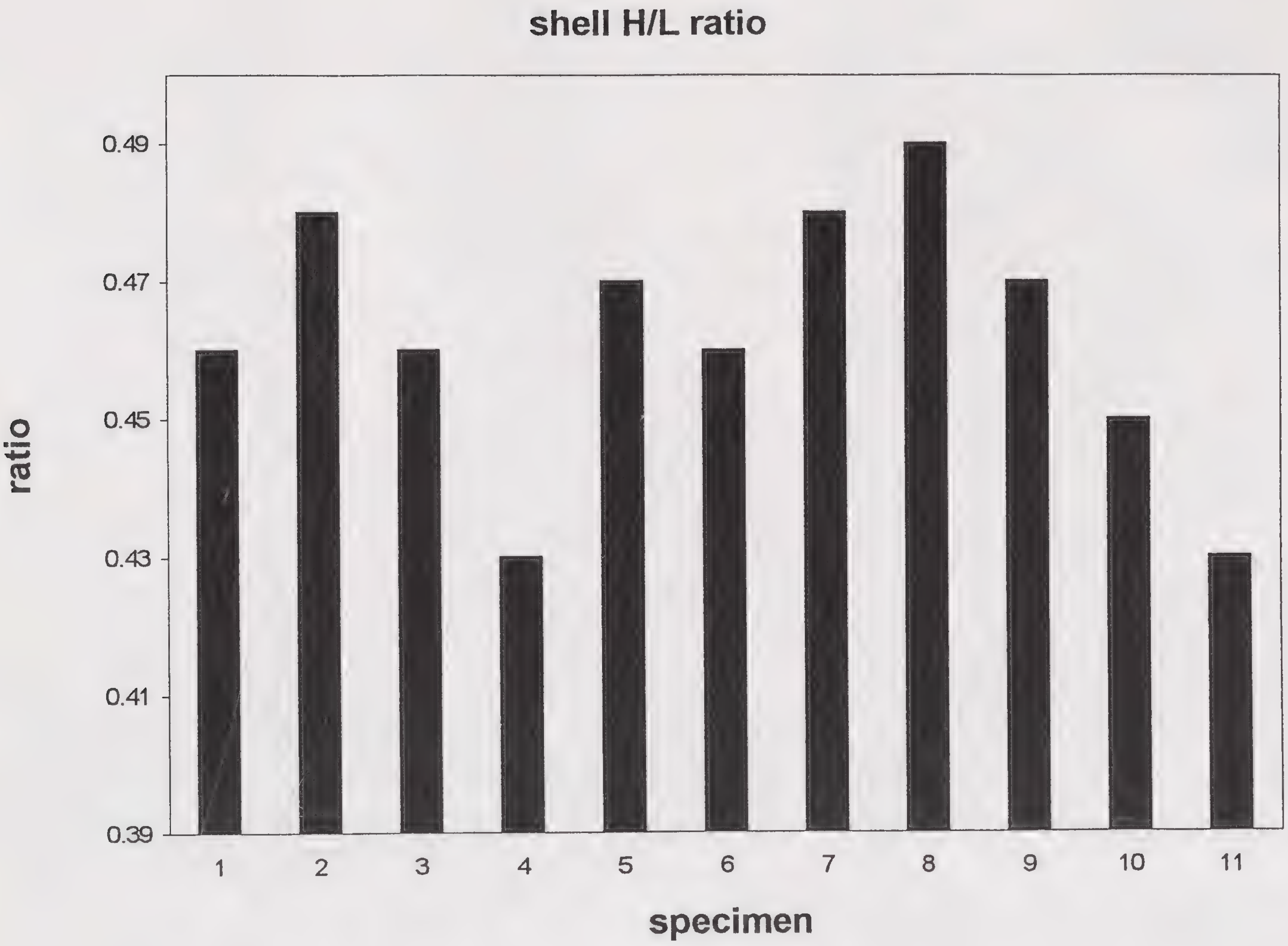


**Fig. 2** Histogram of height / length ratio in *M. dahurica.*

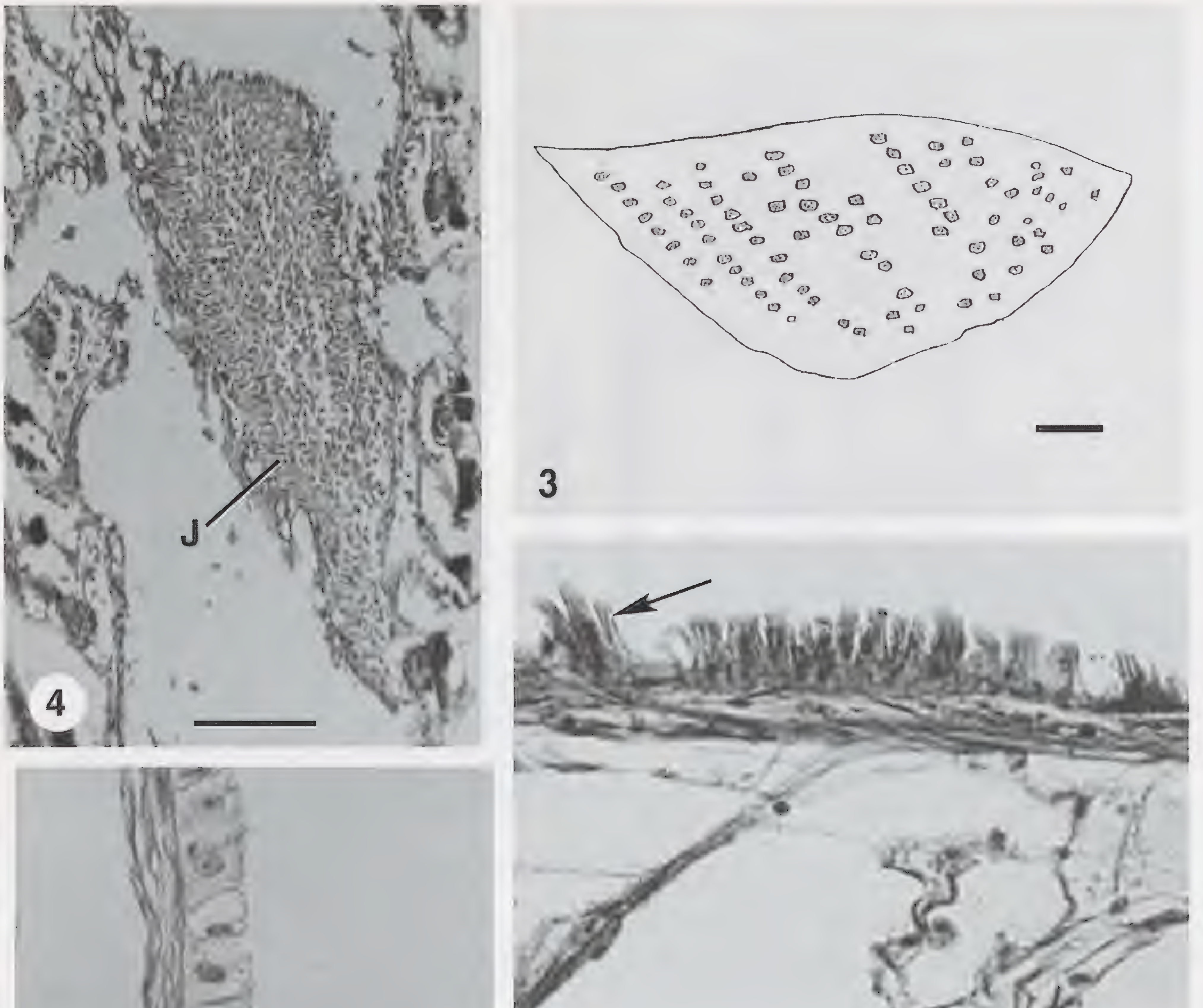
ranging from a few to many. The dentition of the hinge is very reduced in all examined specimens. Laterals are entirely wanting and the pseudocardinals are comprised of small knob-like cusps, the anterior cusp of the left valve being essentially absent altogether. Shell height versus length ratio in studied specimens ranged from 0.43 to 0.49 (X = 0.46, s = 0.02) (Fig. 2).

## ANATOMY

The general anatomy of *M. dahurica* conforms to the bauplan of northern Hemisphere Unionoida. The foot is elongate and is provided with anterior and posterior retractor muscles. A single pair of anterior protractor muscles is situated just ventral to the anterior adductor muscle. The ureter and gonoduct openings are closely set but separate, that of the ureter slightly above the gonoduct. The mantle edges are free posteriorly and there is no tendency to form true siphons.

Specifically, the inner gills are free from the abdominal sac to just anterior of the opening of the gonoduct. The outer gill is subtriangular, the inner gill somewhat oblong (Fig. 3). The gill lamellae are joined by solid vascularized block-like junctions (Fig. 4, see also Smith and Hartel, 1999) and arranged in vague linear oblique rows especially in the center of the gill. Occasionally, several junctions are fused to form short but continuous bands of tissue but usually the junctions are separate and very numerous. The junctions contain transverse connective fibres as described for *Margaritifera margaritifera* (Smith 1979). Posteriorly, the gills are free from the mantle lobes. The mantle lobes are not fused anywhere in the apertural region and the anal opening is continuous nearly to the hinge. On the inner surface of the posterior mantle lobes are well formed diaphragmatic septa (Smith 1980) that couple with the gills to separate inhalant and exhalant currents.

Non-modified mantle epithelial cells are cuboidal or columnar and conjoined (Fig. 5)



**Figs 3–8** Anatomy of *M. dahurica*. **3** Right outer gill, scale equals 5 mm. **4** Transverse section of the gill showing interlamellar junction (J), scale equals 0.25 mm. **5** Typical mantle epithelium, scale equals 25 mm. **6** Modified mantle epithelial junction cells, note dark staining fibrils, scale equals 25 mm. **7** Visceral mass of female showing developed ova, scale equals 0.25 mm. **8** Visceral mass of male showing acini with spermatids and connective tissue (top) of body wall, scale equals 0.25 mm.

without deeply staining properties. Mantle-shell junction regions of the mantle are made up of modified epithelial cells as described by Smith (1983) in other species of the Margaritiferidae. The junction cells are tall columnar cells that have lost cell to cell adhesion properties (Fig. 6). The deep staining quality of these cells is derived in part from the presence of longitudinal fibrils of unknown composition.

The viscera contains a saclike stomach, digestive glands, and a looped intestine which courses between bands of transverse muscle. In none of the specimens was the stomach adequately preserved to reveal details of its construction. The intestine is surrounded by gonadal tissue. All examined animals were either mature males or females and contained active gonads (Figs. 7, 8), however, no females contained eggs or larvae in the gills. No hermaphroditic traits were observed. Based on collection dates, the massed male gametes and supportive products, and the abundant free ova in the acini of females suggests that oviposition occurs in June or July.

The visceral ganglion (Fig. 9) is provided with a pair of anterior connectives communicating with the cerebro-pleural ganglion. The branchial nerves arise laterally on either side and descend into the gill tissue without forming anterior loops. Posteriorly, two large nerves arise which almost immediately divide into mantle and pallial nerves. Occasionally, smaller nerves arise in the vicinity of the pallial-mantle bifurcation or before. No accessory nerves (sensu Smith, 1980, 1988) were observed.

Neither hydracaroid unionicoline mites nor aspidogastrid (trematode) flukes were found in any specimens.

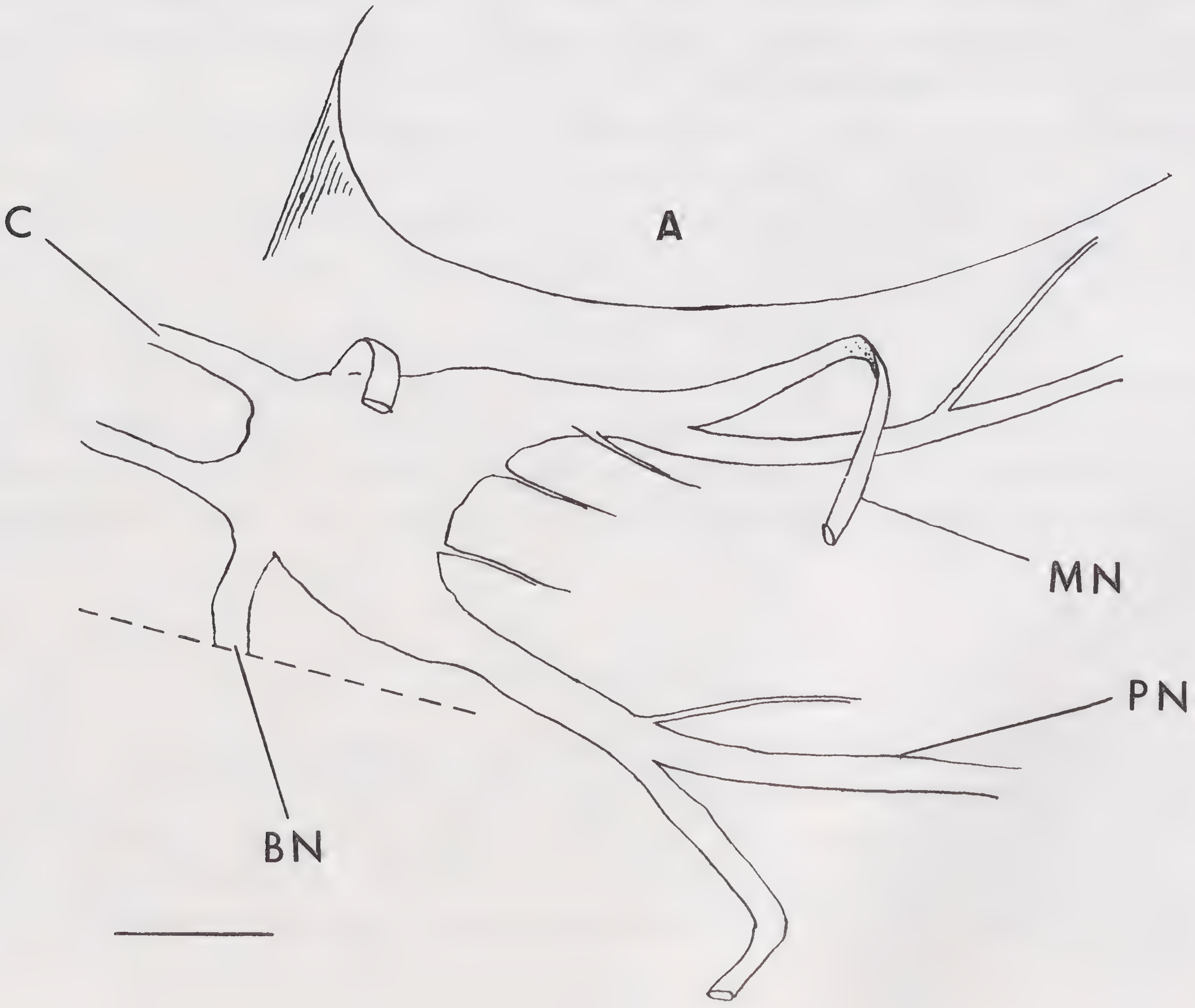


**Fig. 9** Visceral ganglion of *M. dahurica*. **BN** branchial nerve **C** cerebro-pleural commissure **MN** mantle nerve **A** posterior adductor muscle **PN** pallial nerve. Scale bar =1 mm.

## DISCUSSION

The question of whether two or a single described taxon occurs in the sample must first be addressed. Moskvicheva (1973) described *Margaritinopsis sujfunensis* (Fig. 1) based on specimens collected in drainage systems near Ussuriysk, in the Ussuri River basin, Maritime region. The principal characteristic separating this species from *M. dahurica* is that the shell of *M. sujfunensis* is "higher" than that of *M. dahurica*, expressed as the height/length ratio (Moskvicheva, 1973). The given ratios are 0.38–0.44 for *M. dahurica* and 0.45–0.50 for *M. sujfunensis.* Similar measurements from examined specimens including a paratype each of *M. dahurica* and *M. sujfunensis* revealed a H/L ratio range inclusive of both species with a very narrow range of variation. As can be seen in Fig. 2, the majority of specimens, including the paratype of *M. dahurica* (#5) from the western most Amur River basin, are within the range of *M. sujfunensis.* The H/L ratio of the paratype of *M. sujfunensis* (#4) examined actually falls within *M. dahurica.* Notwithstanding the small sample size, the narrow range of ratios, the broad variation within these ratios among several widely dispersed populations, and the failure of a paratype of *M. sujfunensis* to fall within the specified range for the species all suggest that a single species, *M. dahurica,* is represented, as inferred by Smith (1980) and Ziuganov *et al.* (1994).

Anatomically, *M. dahurica* unquestionably belongs in the Margaritiferidae. The gross morphology of the gills, their relationship with the mantle especially posteriorly, and the presence of mantle-shell attachment cells is consistent with other species of Margaritiferidae in which the anatomy is known. Otherwise, *M. dahurica* differs from all other known margaritiferids by its extremely thin and compressed shell. Otherwise, concologically, it is most similar to *Margaritinopsis monodonta* of the North American interior in that the adult dentition is highly reduced so that only weak and nearly functionless pseudocardinal teeth remain.

The triangular shaped outer gill with mostly separate interlamellar junctions is closest to *Margaritifera margaritifera, Pseudunio hembeli,* and *P. marrianae.* Although the morphology of the visceral ganglion in not yet known in several species of margaritiferids there appears to be differences among species which have been studied. The visceral ganglion and associated nerves of *M. dahurica* exhibit features most like *P. hembeli* of the Gulf Coast region of North America. In both species there is no accessory nerve (sensu Smith, 1980) extending from the ganglion to the mantle nerve. In addition, the bifurcation of the pallial and mantle nerves occur close to the ganglion. In *Margaritifera margaritifera* and *Margaritinopsis monodonta,* and some *Pseudunio marrianae,* there is an accessory nerve and in the former two species the main bifurcation occurs well away from the ganglion.

## CONCLUSION

*Margaritinopsis dahurica* is a distinct species among the Margaritiferidae. The characters of the shell, in combination, are unique among the described species. The reduced dentition, particularly the near absence of the anterior cusp of the left pseudocardinal tooth, relates *M. dahurica* to all other Asian and western North American taxa. Anatomically the species shows no unique characters, however, no Asian margaritiferids have been studied in detail.

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# *MELANOPSIS* FROM THE MID-PLEISTOCENE SITE OF GESHER BENOT YA'AQOV (GASTROPODA: CERITHIOIDEA).

J. Heller[1] & N. Sivan[1]

*Abstract Gesher Benot Ya'aqov is a 780,000 yr. old mid-Pleistocene site in the Hula Valley (Israel). Its rich* Melanopsis *fauna was found to include seven species:* buccinoidea *Olivier,* costata *Olivier (with two ill-defined forms, shouldered and conic),* obediensis *Picard,* corrugata *Schütt,* vincta *Blanckenhorn,* sigmocorrugata *n. sp. and* turriformis *Picard (with three ill-defined forms, 'typical', 'ivory' and 'gray-orange').*

*Within the Jordan Valley, the* Melanopsis *faunal assemblage of Gesher Benot Ya'aqov is broadly similar to that of 'Ubeidya. Beyond the Jordan Valley three species of Gesher Benot Ya'agov occur also in Plio-Pleistocene sites of the Orontes, thereby weakening arguments that the fauna of the Jordan evolved independently of the Orontes catchment area.*

*Most shells at Gesher Benot Ya'aqov fall into clearly distinct species. However, intermediates are found between* vincta *and* corrugata *and between* buccinoidea *and* turriformis. *The occasional occurrence of the* buccinoidea-turriformis *intermediates within the layers of Gesher Benot Ya'aqov suggests that they are hybrids (rather than representatives of gradual evolutionary transition). Similarly among Recent* Melanopsis, *smooth-shelled buccinoidea and costate-shelled* costata *almost always remain distinct, but in zones of contact hybrids with intermediate shells may be found, at low frequencies and over short distances.*

*Key words* Melanopsis, *Pleistocene, Gesher Benot Ya'aqov, Systematics, Jordan Valley, hybrids*

## INTRODUCTION

The freshwater snail *Melanopsis* Férussac 1807 (Melanopsidae) has a broadly circum-Mediterranean distribution and its many isolated populations exhibit widely divergent shell phenotypes. The systematics, distribution and extent of hybridization of recent *Melanopsis* in the Jordan Valley have recently been described, as concerns conchiometrics, sperm and allozymes by Heller *et al.* (1999) and Heller & Sivan (2000), Heller & Hodgson (2000) and by Falniowski *et al.* (submitted), respectively. This present paper concerns fossil *Melanopsis* from Gesher Benot Ya'aqov, a mid-Pleistocene site in the Hula Valley (Fig. 2).

The Hula Valley is the smallest and northernmost basin of the Jordan catchment area. It is fed by the waters of the Jordan River, flowing from the north toward the Dead Sea. Until recently, a lake bordered by extensive swamps occurred in the valley; these were drained in the 1950s. Gesher Benot Ya'aqov is an open-air, water-logged, 780,000 yr. old mid-Pleistocene site, just beyond the outlet of this sub-Recent lake (Goren-lnbar & Belitzky, 1989). First surveyed in the 1930s, investigations were recently resumed by Goren-lnbar (see Goren-Inbar & Belitzky, 1989) who excavated lacustrine-fluvial deposits 34 m thick. Some of these sediments were rich in *Melanopsis* remains; this paper describes their systematics.

## METHODS

Material reached the laboratory either in primordial form, or as a mixture of shells separated from the mud at the site. From this material we separated the *Melanopsis* remains, for further examination.

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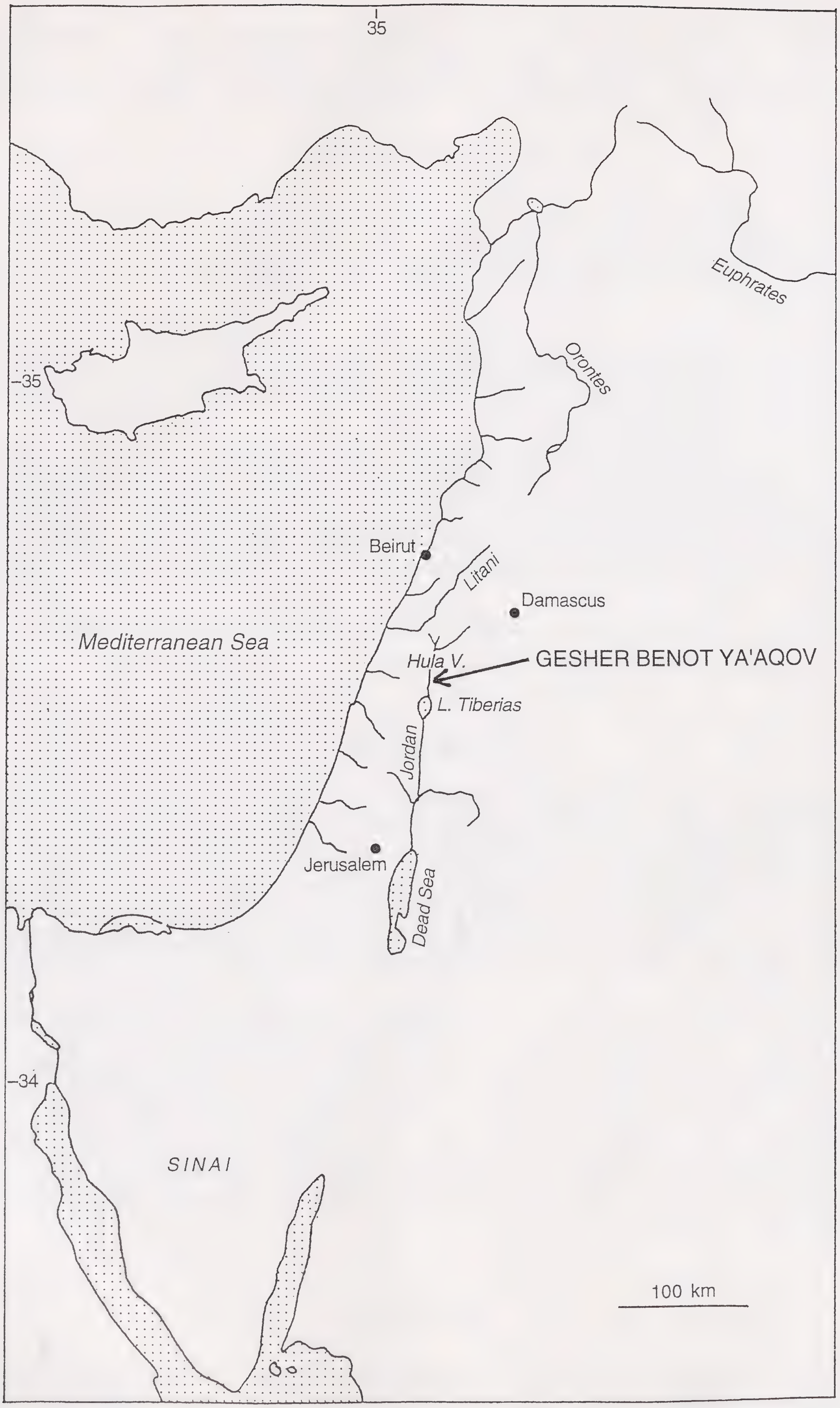

**Fig. 1** The Levant, showing Gesher Benot Ya'aqov.

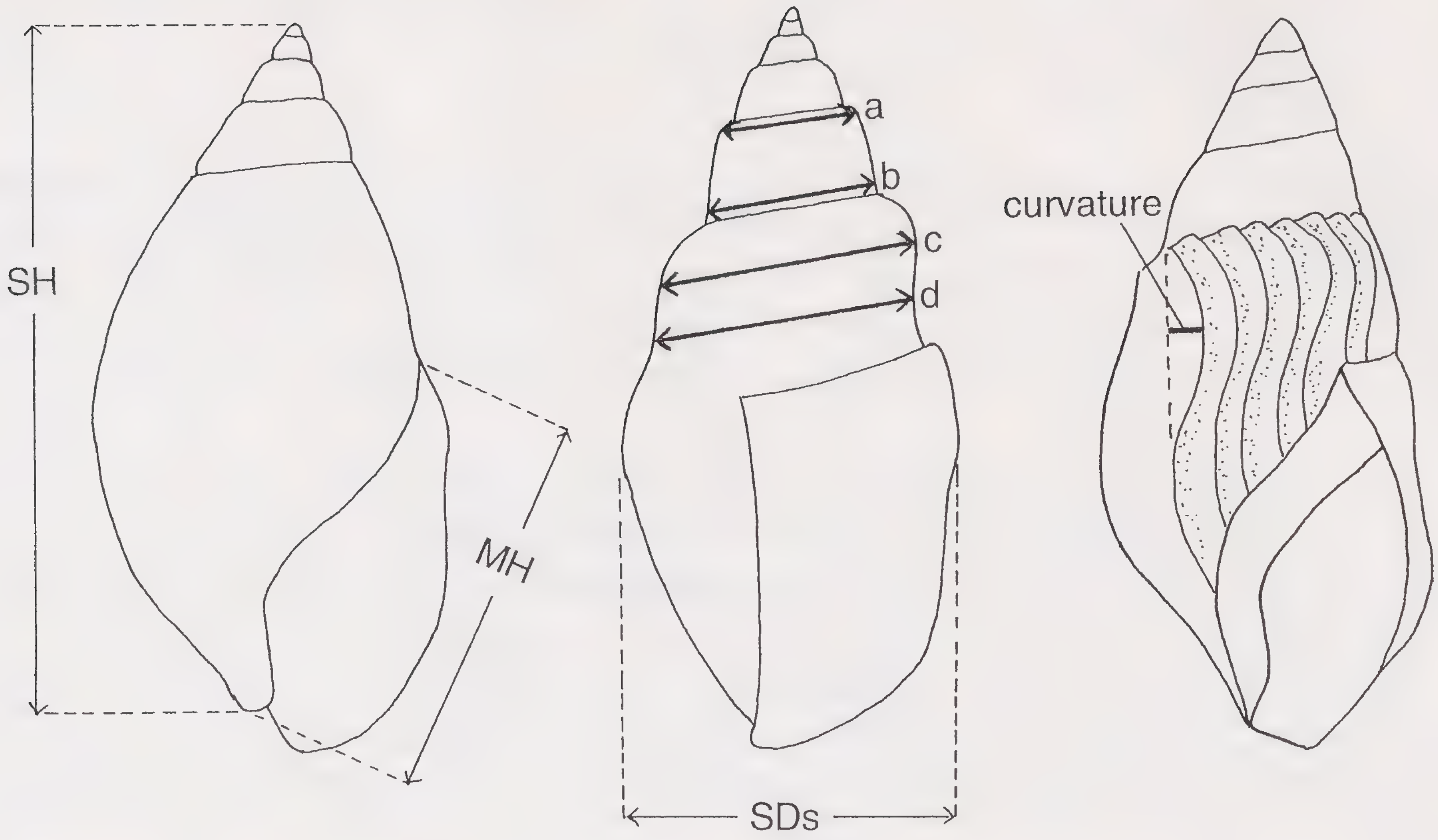

**Fig. 2** Shells of *Melanopsis* from different angles to show measurements used in this study. **SH** shell height **SDs** small shell diameter **MH** mouth height.

## MEASUREMENTS AND RATIOS

When possible, 20 shells of each taxon were measured. To express general shape of the shell we applied the conchiometrics used in our study of Recent *Melanopsis*, but adjustments were necessary because most shells were broken at the aperture. We therefore measured small (rather than big) shell diameter. General conchiometrics in this study thus include shell-height, shell-diameter (small) and mouth-height; all measured with a caliper accurate to 0.1 mm (Fig. 2). From these measurements three ratios were calculated (that differ slightly from the corresponding ratios of Heller *et al.*, (1999): shell-diameter(s)/shell-height, mouth-height/shell-height and mouth-height/shell-diameter(s).

In addition, the diameter of the shell was measured at four different points (a, b, c and d) under the binocular microscope, using the eye-piece micrometer (Fig. 2). From these measurements, to express the extent of shell shouldering quantitatively we calculated the ratio b / c. To express the extent of shell figurativity ('waist'), we calculated the ratio c / d. To express the extent to which whorls are conic ('conicality'), we calculated the ratio a/b.

To measure rib characteristics, each shell was scored for presence or absence of ribs. When ribs were present, three rib characteristics were scored:

- Rib number, from uppermost point of insertion of the aperture on the body whorl rightways, to the corresponding point on the penultimate whorl.
- Rib density, number of ribs from uppermost point of insertion of aperture 5 mm leftwards, counted under the micrometer of the binocular.
- Rib length, examined on body whorl.

This characteristic is continuous. To describe increasing rib length four categories were erected, and numbered 1–4:

1. ribs very short, do not reach the shell aperture.
2. ribs reach from the suture down to the aperture.

3. ribs reach beyond the aperture but do not extend the entire height of the body whorl; usually they reach midway down the aperture.
4. ribs reach the entire height of the body whorl.

To measure the extent to which ribs are wavy (rather than straight) curvature was measured on the fifth rib of the body whorl (to the left of the aperture) using the eye-piece micrometer of the binocular (Fig. 2). Curvature is the distance (mm) by which a wavy rib deviates from an imaginary straight line that connects the upper and lower part of the rib. We distinguished ribs that curve to the left from those that curve to the right.

To express the height to which ribs project beyond the shell, in 25 shells from five different layers rib height was also measured: each shell was first cut with a delicate disc-saw to obtain a cross-section and then abraded with an electric grindstone, down to a standard level (through the lower whorl, at the uppermost corner of the shell aperture + 1 mm). In this cross-section, shell height was measured (with a micrometer) at the centre and on both sides of the most prominent rib. Rib height was defined as the measurement at rib centre, minus the measurement at (averaged) rib side (Heller *et al.*, 1999; Fig. 1).

## CLUSTER ANALYSIS

The cluster analysis presented in the dendrograms of Fig. 8 was performed by calculating the standardized Euclidean distance between the taxa.

## RESULTS

The *Melanopsis* species found at Gesher Benot Ya'aqov are illustrated in Fig. 3, and are hereby described. Six trenches dug during the excavation are referred to by Roman letters, and we sometimes refer to layers within these trenches. In general however, this paper pools data of all layers. A detailed chrono-analysis of the *Melanopsis* species within Gesher Benot Ya'aqov will be published separately, once the precise stratigraphy of the site is worked out.

### *Melanopsis buccinoidea* (Olivier)
Fig. 3A

*M. buccinoidea* (Olivier 1801, pl. 17 Fig. 8).
*Melanopsis praemorsa* f. *praemorsa* Ohlhorst & Hutchinson (1977), Pl. 1 Fig. F.
*Melanopsis* Type "A" Moshkovitz & Magaritz 1987 (Fig. 3C).

*Diagnosis* A recent species of the genus *Melanopsis* Férussac 1807, that occurs also today in the Jordan Valley, *M. buccinoidea* differs from *M. praemorsa* L., the type species of *Melanopsis* (from Spain) in its larger, less ventricose shell (Pallary, 1939).

*Description* The shell has up to seven whorls. It has a pointed spire, flattened whorls separated by very shallow sutures, and is smooth.
*Measurements* Measurements and ratios of *M. buccinoidea* from Gesher Benot Ya'aqov (layers IV–7 and II–8 pooled, n=16):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 21.5 mm | |
| shell-diameter (s) | up to 9.5 mm | |
| mouth-height | up to 12.0 mm | |
| shell-diameter (s) / shell-height | 0.44–0.49 | 0.46 ± 0.02 |
| mouth-height / shell-height | 0.49–0.60 | 0.56 ± 0.03 |
| mouth-height/shell-diameter (s) | 1.12–1.36 | 1.21 ± 0.08 |
| conicality | 0.66–0.83 | 0.70 ± 0.05 |
| figurativity | 0.86–0.92 | 0.89 ± 0.02 |
| shouldering | 0.67–0.85 | 0.80 ± 0.06 |

*Material* 265 shells. In addition, 53 shells were found that are intermediate between *buccinoidea* and *turriformis* (in that they are generally smooth but with a few faint traces of ribs).

*Remarks* Most shells are either small, broken or eroded. They are assigned to *buccinoidea* because they are smooth and stout (as in Recent shells where the ratio shell-diameter (s) / shell-height is, similarly, 0.46 ± 0.02). Also *M. praemorsa* f. *praemorsa* of Ohlhorst & Hutchinson (1977 Pl. 1f) and *M.* Type "A" of Moshkovitz & Magaritz (1987 Fig. 3C) are smooth and stout, whereby we consider them synonyms. *Buccinoidea* is the oldest name of a smooth-shelled *Melanopsis* from the Levant. The type species of *Melanopsis*, *M. praemorsa* L., occurs in Spain; it too is smooth-shelled but is described as differing from *M. buccinoidea* in its smaller, more ventricose shell (Heller *et al.* 1999; see also Pujante *et al.*, 1988, Fig. 1). To discover if *M. buccinoidea* is a species completely separate from *M. praemorsa*, a subspecies within a big *M. praemorsa* superspecies or merely a synonym of *praemorsa*, is beyond the scope of this present study.

### *Melanopsis costata* (Olivier)
Figs. 3B, C

*Melania costata* Olivier 1804, pl. 31 Fig. 3.
*Melanopsis* type F Moshkovitz & Magaritz 1987, Fig. 3-f.
*Melanopsis blanckenhorni* Schütt 1987, Pl. 3, Figs 18–20.
*Melanopsis blanckenhorni* Schütt & Ortal 1993, Pl. 2, Fig. 17.
*Melanopsis obediensis coroniformis* Schütt & Ortal 1993, Pl. 2, Fig. 26.

*Diagnosis* A recent species of the genus *Melanopsis* Ferussac, 1807, *M. costata* differs from *M. buccinoidea* in that it is ribbed. The number of ribs is almost always less than 13.

*Descriptions and comments* Within recent *M. costata* of the Jordan Valley, we distinguished (Heller *et al.*, 1999) three groups that may be subspecies and tentatively assigned them the names *M. c. costata*, *M. c. jordanica* Roth and *M. c. noetlingi* Bourguignat. In Gesher Benot Ya'aqov we found two groups that differ significantly, but not always diagnostically. They may be subspecies, and may be related to the recent forms. We tentatively name them *M. costata*-shouldered and *M. costata*-conic.

*M. costata*-shouldered (Fig. 3B) is characterized by its slim, turreted shell with pronounced ribs that extend the entire length of the whorl. The aperture is small, in relation to shell-height. The overall appearance of the shell is heavily shouldered. The whorls are very strongly ribbed. In some shells each rib consists of an upper tubercle, fused to a straight lower ridge, with which it is continuous. The ribs extend vertically, the entire height of each whorl. The lower ridge of the ribs bend leftwards, towards the base of the columella.

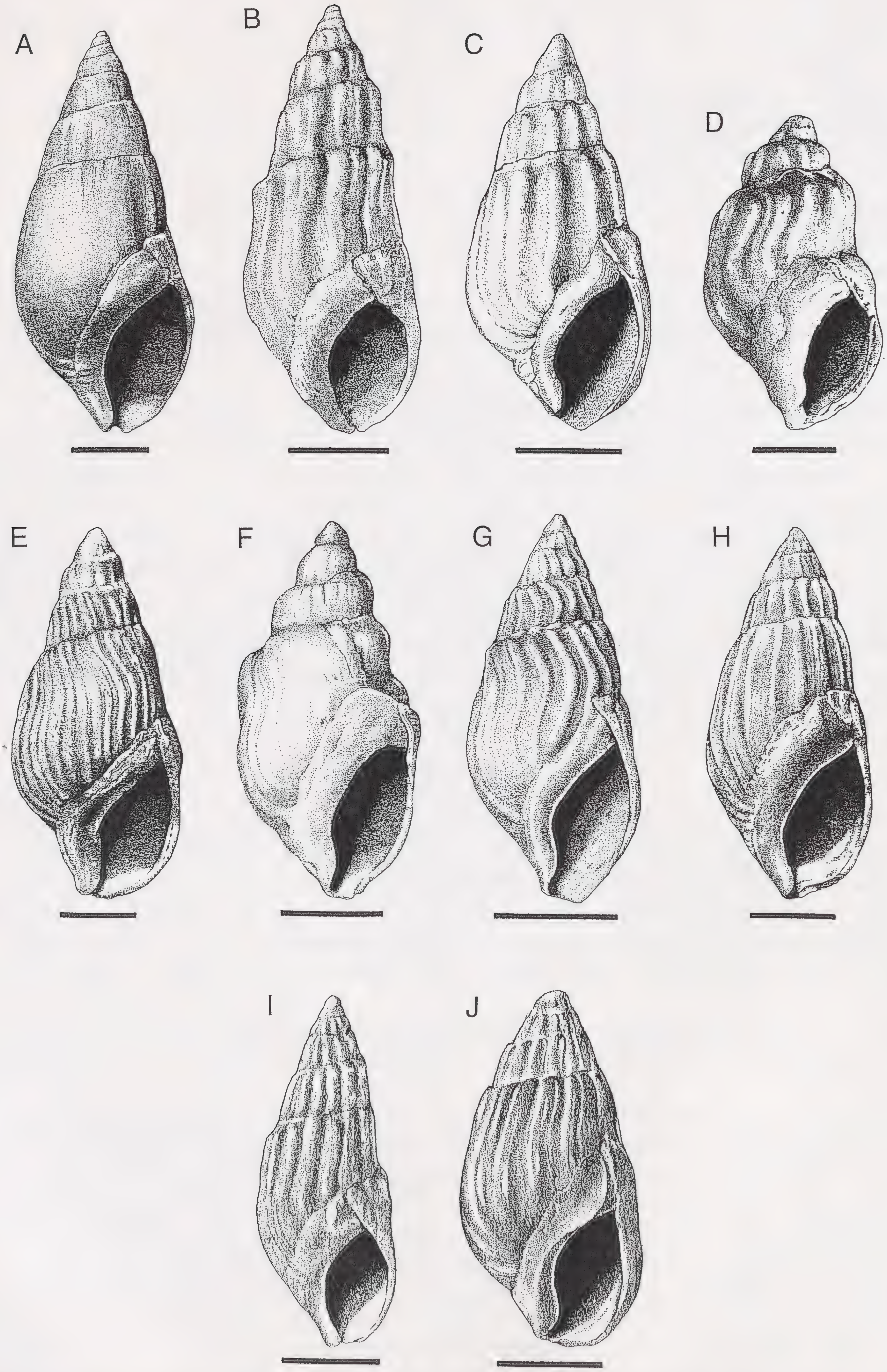

**Fig. 3** *Melanopsis* species of the Gesher Benot Ya'aqov **A** *M. buccinoidea*. **B** shouldered *M. costata*. **C** conic *M. costata*. **D** *M. obediensis*. **E** *M. corrugata*. **F** *M. vincta*. **G** *M. sigmocorrugata*. **H** *M. turriformis*. **I** *M. turriformis* complex ('ivory'). **J** *M. turriformis* complex ('grey orange'). Scale bar = 5mm.

*Measurements* Measurements and ratios of *M. costata*-shouldered from Gesher Benot Ya'aqov (layer III–8, n=20):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 23.2 mm | |
| shell-diameter (s) | up to 9.0 mm | |
| mouth-height | up to 9.2 mm | |
| shell-diameter (s) / shell-height | 0.39–0.46 | 0.42 ± 0.02 |
| mouth-height / shell-height | 0.40–0.48 | 0.43 ± 0.02 |
| mouth-height / shell-diameter (s) | 0.90–1.11 | 1.03 ± 0.05 |
| conicality | 0.86–0.96 | 0.92 ± 0.02 |
| figurativity | 0.92–1.00 | 0.96 ± 0.02 |
| shouldering | 0.73–0.86 | 0.80 ± 0.04 |
| rib number | 10–12 | 11.20 ± 0.77 |
| rib density | 2.0–3.0 | 2.80 ± 0.30 |
| rib length | all 4 | 4 |
| rib curvature | all 0 | 0 |

*Material* 166 shells.

*Remarks* As compared to Recent shells, *M. costata*-shouldered is closely similar to co-types of *M. costata* as illustrated from the type locality Jiser esh Shugur (Syria) by Pallary (1939 Pl. V, Figs 26–28 and 30– 36). Perhaps it should therefore be considered the type subspecies, *M. c. costata*. However, as the type locality is inaccessible to us, we prefer to postpone this decision. Of the sites available to us, *costata*-shouldered is closely similar to *M. costata* from the lower reaches of the Lower Jordan River (Qasr-el-Yahud, 4 km S of Allenby bridge, 7 km N of Dead Sea, 7 km E of Jericho, IG 201138), which also have slim shells with pronounced ribs that extend the entire width of the whorl. Conchiometrics of these Recent shells from Allenby Bridge are (n= 20):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 21.9 mm | |
| shell-diameter (s) | up to 9.1 mm | |
| mouth-height | up to 11.0 mm | |
| shell-diameter (s) / shell-height | 0.36–0.44 | 0.40 ± 0.02 |
| mouth-height / shell-height | 0.43–0.55 | 0.50 ± 0.03 |
| mouth-height / shell-diameter (s) | 1.11–1.35 | 1.24 ± 0.06 |
| conicality | 0.88–0.98 | 0.91 ± 0.02 |
| figurativity | 0.92–1.00 | 0.96 ± 0.02 |
| shouldering | 0.65–0.94 | 0.79 ± 0.06 |
| rib number | 10–12 | 9.95 ± 1.00 |
| rib density | 2.5–4.0 | 3.10 ± 0.48 |
| rib length | all 4 | 4 |
| rib curvature | all 0 | 0 |

The *M. costata*-shouldered of Gesher Benot Ya'aqov (layer GBY 111–8) are similar to these Recent Lower Jordan *M. costata* in overall shape (the ratio shell-diameter (s) / shell-height), conicality, figurativity, number of ribs and rib density (t-test). They differ in their relatively smaller mouth height, as expressed in lower values of the ratios mouth-height / shell-height and mouth height / shell-diameter (s) (t-test); and in that their ribs are more pronounced. Also the *M. costata* illustrated by Glaubrecht (1993) from the Lower Jordan (near Kloster Prodromer) seems identical to *M. costata*-shouldered (Pl.

1 Fig. 13; especially the highest shell in the series; see also Glaubrecht 1996 Pl. 7 Fig. 13). To conclude we consider *M. costata*-shouldered and the Lower Jordan *M. costata* as identical.

The pronounced ribs may perhaps place the shouldered shells close to *noetlingi* Bourguignat of the Yarmouk, which is however more stout. It is unfortunate that the Yarmouk and large parts of the Lower Jordan River are both rather inaccessible. Fossil *noetlingi* have been described by Picard (1934) from 'Erq el-Ahmar, which dates about 2 my ago (Tchernov 1993).

Schütt (1987, Pl. 3, Figs 18–20) described *Melanopsis blanckenhorni* from an upper Pliocene site in Syria (the Orontes, S of Jiser esh Shugur), as characterized by a relatively large, narrow shell (shell-height = 25 mm, small shell-diameter= 10 mm) with broad, widely-spaced, straight ribs. In both the Recent material from Gesher Allenby and the fossil material from Gesher Benot Ya'aqov, shell size reaches only 90% of these measurements. This difference is slight, when we consider the 300–500 km gap in distance, and the 1–2 My gap in time, between the Upper Pliocene of Syria and the Pleistocene–Holocene of Israel. We consider *M. blanckenhorni* a synonym of *costata*.

*M. costata*-conic (Fig. 3C) differs from *costata*-shouldered in its more conic whorls and sharp ribs. The shell is broad and its aperture is big, in relation to shell-height. The overall appearance of the shell is conic (not heavily shouldered). The ribs are well-pronounced and extend vertically, the entire height of each whorl. The upper part of each rib is rounded.

*Measurements* Measurements and ratios of *M. costata*-conic from Gesher Benot Ya'aqov (Layer GBY III–9, n=20):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 20.0 mm | |
| shell-diameter (s) | up to 8.8 mm | |
| mouth-height | up to 9.0 mm | |
| shell-diameter (s) / shell-height | 0.43–0.51 | 0.46 ± 0.02 |
| mouth-height / shell-height | 0.43–0.53 | 0.47 ± 0.02 |
| mouth-height / shell-diameter (s) | 0.96–1.11 | 1.04 ± 0.05 |
| conicality | 0.80–0.90 | 0.85 ± 0.03 |
| figurativity | 0.91–0.95 | 0.93 ± 0.01 |
| shouldering | 0.72–0.86 | 0.79 ± 0.03 |
| rib number | 10–14 | 11.65 ± 0.99 |
| rib density | 2.5–4.0 | 3.05 ± 0.39 |
| rib length | all 4 | 4 |
| rib curvature (left) | 0–0.6mm | 0.14 ± 0.26mm |

*Material* 188 shells.

*Remarks* *M. costata*-conic differs significantly from *costata*-shouldered, of GBY 111–8, in its higher ratios shell-diameter (s) / shell-height and mouth-height / shell-height; and lower figurativity and conicality. These shells are broadly similar to Recent *c. costata* from the Hula Valley (Heller *et al.*, 1999). They differ significantly in the ratio mouth-height / shell-height, which in Recent shells is higher (0.54 ± 0.03, 0.46–0.61); and in the ratio mouth-height / shell-diameter (s), which in Recent shells is higher (1.21 ± 0.06, 1.08–1.37).

In layer GBY III–8 the Lower-Jordan and conic forms occur together, and it is not always possible to classify each individual shell.

### *Melanopsis obediensis* Picard 1934
Fig. 3D

*Melanopsis obediensis* Picard 1934, Pl. 7 Figs 30–52.
*Melanopsis obediensis coroniformis* Schütt & Ortal 1993, Pl.2, Fig. 26.
*Melanopsis* Type "D" Moshkovitz & Magaritz 1987, Fig. 3I.

*Diagnosis* A fossil species of the genus *Melanopsis* Ferussac,1807, *M. obediensis* differs from *costata* of Gesher Benot Ya'aqov in that the ribs of the ultimate whorl curve to the left (Fig. 4).

*Measurements* Measurements and ratios of *M. obediensis* from Gesher Benot Ya'aqov (Layers GBY II–14 and II–17, n=15):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 17.8 mm | |
| shell-diameter (s) | up to 8.3 mm | |
| mouth-height | up to 8.5 mm | |
| shell-diameter (s) / shell-height | 0.44–0.58 | 0.50 ± 0.04 |
| mouth-height / shell-height | 0.43–0.56 | 0.50 ± 0.04 |
| mouth-height/shell-diameter(s) | 0.79–1.16 | 1.00 ± 0.09 |
| conicality | 0.91–0.96 | 0.94 ± 0.02 |
| figurativity | 0.95–1.01 | 0.98 ± 0.02 |
| shouldering | 0.60–0.75 | 0.68 ± 0.05 |
| rib number | 9–14 | 11.47 ± 1.25 |
| rib density | 2–4.0 | 3.27 ± 0.28 |
| rib length | 3.5–4.0 | 3.97 ± 0.13 |
| rib curvature (left) | 0.5–1.5 mm | 0.94 ± 0.25 mm |

*Material* 37 shells.

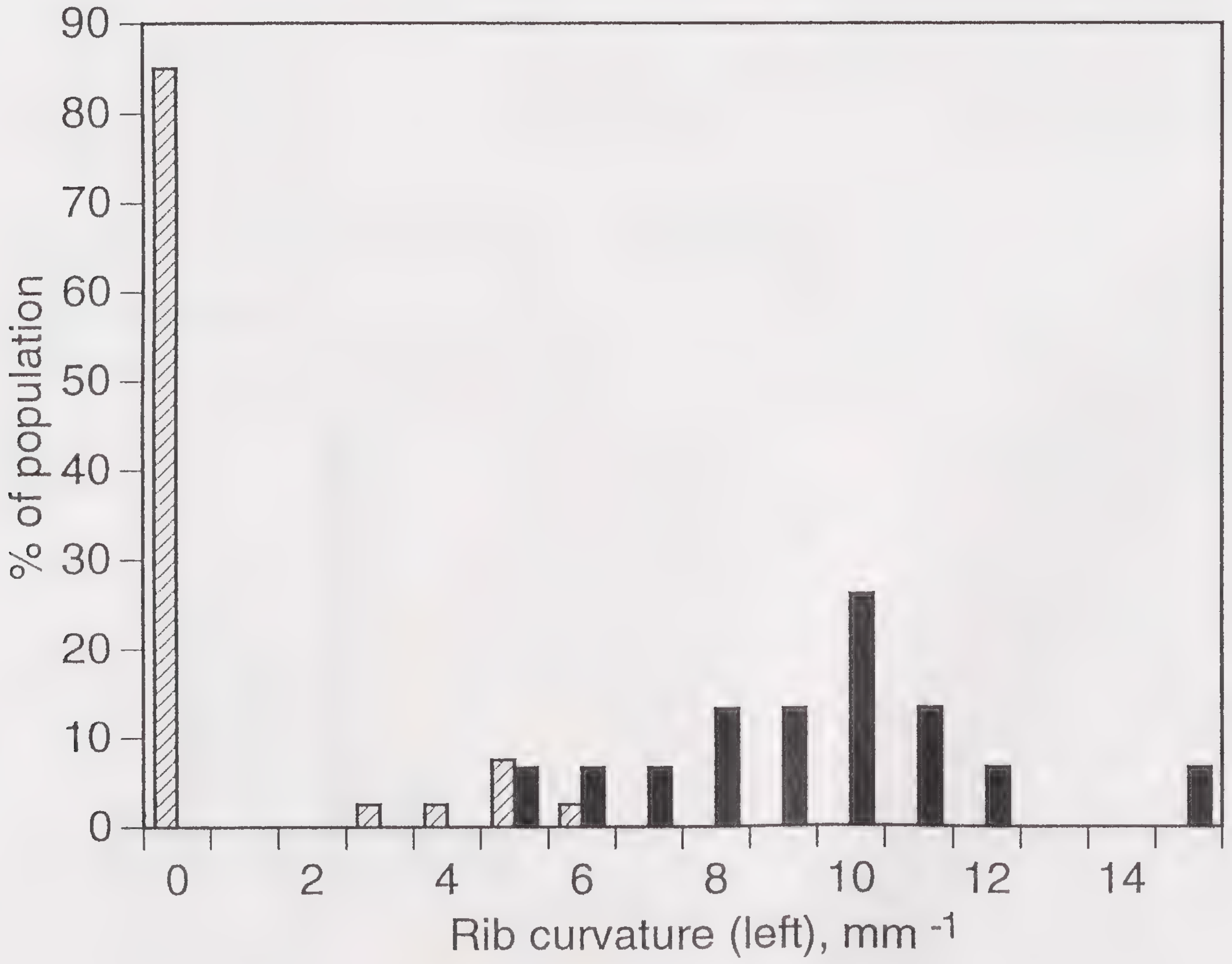

**Fig. 4** Rib curvature frequency in *Melanopsis obediensis* (black) and *M. costata* (both conic and shouldered; hatched).

*Remarks* Picard (1934; Pl. 7 Figs 30–52) described *Melanopsis obediensis* (from strata in the Yarmouk outlet) as having few widely-spaced, sigmoid ribs that are thickened (but not knob forming) in their upper parts. Schütt & Ortal (1993 Pl. 2 Fig. 26) illustrated *M. obediensis coroniformis* from Gesher Benot Ya'aqov. They do not offer measurements; however their figure seems so similar to our *M. obediensis* that we consider it a synonym. Moshkovitz & Magaritz (1987, Figs 3H and 3I) described from Gesher Benot Ya'aqov a 'distorted form' (*Melanopsis* type D), characterized by a thick shell and prominent sigmoid whorls. Their Fig. 3I seems so similar to our *M. obediensis* that we consider it a synonym.

The *M. obediensis* of Gesher Benot Ya'aqov differ from those illustrated by Picard in his description of the species in that they are narrower and have higher rib density.

### *Melanopsis corrugata* Schütt
Fig. 3E

*Melanopsis corrugata* Schutt & Ortal 1993, Pl. 2, Figs 15–16. ?
*Melanopsis* sancta Blankenhorn 1897, Pl. 10 Fig. 6.
*Melanopsis praemorsum* Tchernov 1973, Pl. 3 Fig. 2.
*Melanopsis* Type "E" Moshkovitz & Magaritz 1987, Fig 3J.
*Melanopsis* Type "F" Moshkovitz & Magaritz 1987, Fig. 3K; Fig. 3L.

*Diagnosis* A fossil species of the genus *Melanopsis* Ferussac, 1807, *M. corrugata* has 15–27 ribs. In this it differs almost always from *M. costata,* in which the number of ribs is 9–14 (and which is found with *M. corrugata* in the same strata).

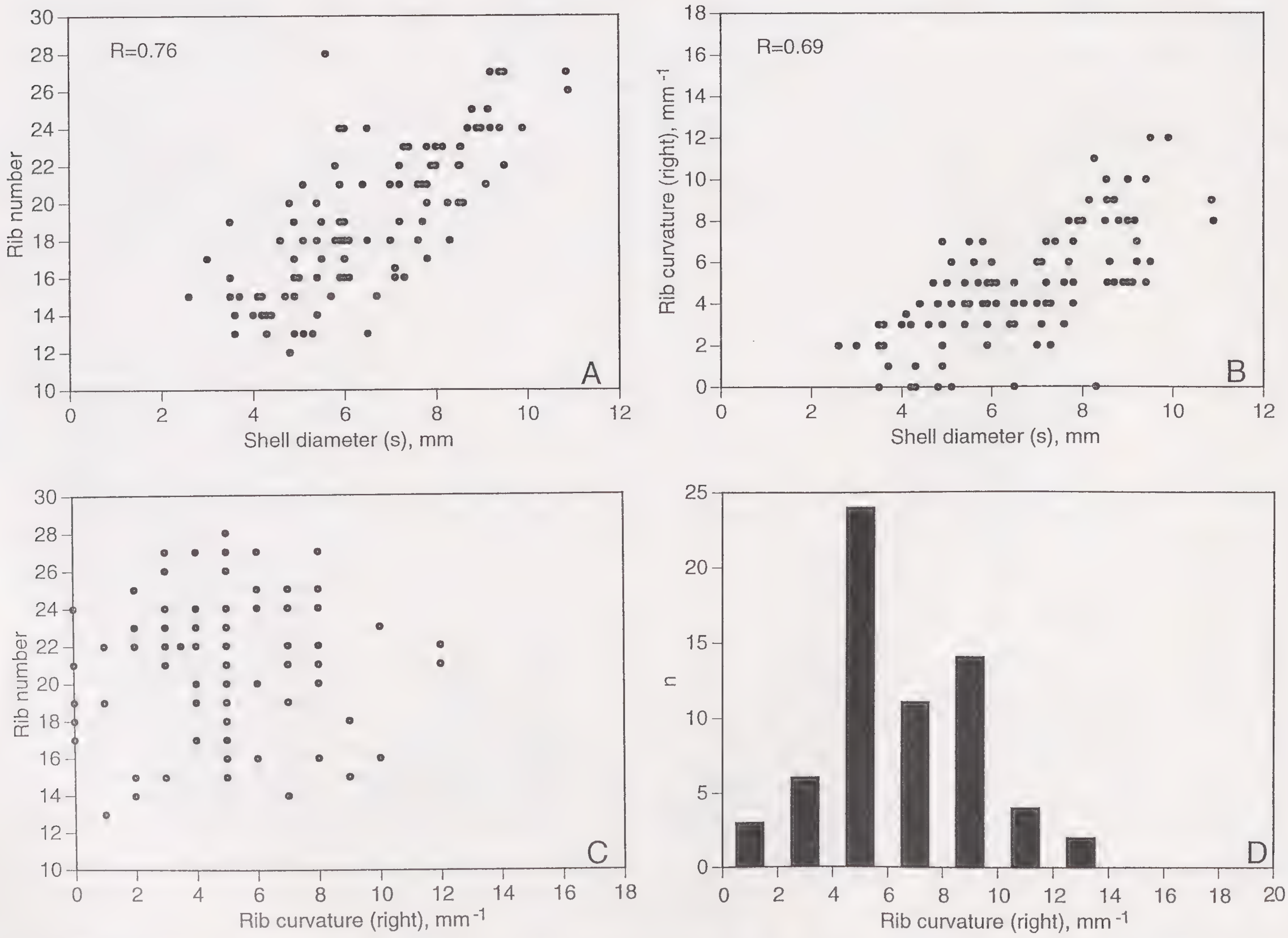

**Fig. 5** *Melanopsis corrugata* **A** Shell diameter (small) versus rib number. **B** Shell diameter (small) versus rib curvature. **C** Rib curvature versus rib number. **D** Frequency of rib curvature in shells above 6 mm shell diameter (small).

*Description* The shell is tall, has up to eight whorls, and its overall contour is usually shouldered; sometimes the last whorl is slightly indented. The first 1–3 whorls are smooth. The 4–5 lower whorls are covered with 15–27 delicate ribs, that extend vertically the entire height of each whorl and almost always descend straight downward, parallel to the axis of the shell. In some shells the ribs are slightly wavy: the upper part of each rib bends slightly to the right; the lower part may bend slightly to the left, or it may descend straight downward, parallel to the axis of the shell. Right curvature, in shells of above 6 mm small shell-diameter, is almost always less than 1.0 mm (Fig. 5B). The upper part of each rib may have a small knob, ridge or bump, beyond which it may slant at an angle towards the suture above it, giving the shell a slightly stepped contour.

*Measurements* Measurements and ratios of *M. corrugata* from Gesher Benot Ya'aqov (Layer GBY V–5, n=20):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 24.8 mm | |
| shell-diameter (s) | up to 10.9 mm | |
| mouth-height | up to 12.8 mm | |
| shell-diameter (s) / shell-height | 0.35–0.55 | 0.46 ± 0.03 |
| mouth-height / shell-height | 0.41–0.61 | 0.53 ± 0.04 |
| mouth-height/shell-diameter(s) | 1.02–1.25 | 1.16 ± 0.05 |
| conicality | 0.81 –1.00 | 0.92 ± 0.04 |
| figurativity | 0.86–0.99 | 0.94 ± 0.03 |
| shouldering | 0.64–0.98 | 0.77 ± 0.05 |
| rib number | 15– 27 | 21.0 ± 3.41 |
| rib density | 4.5–10 | 6.81 ± 1.17 |
| rib length | all 4 | 4 |
| rib curvature (right) | 0.4–1.2 mm | 0.66 ± 0.21 mm |

*Material* 2086 shells.

*Remarks* Rib number and rib curvature increase with size (Fig. 5A, B). In comparing shells from different layers (V–5 versus II–5) we found that rib height in V–5 was 0.16 ± 0.05 mm, versus 0.28 ± 0.08 mm in II–5 (each layer five honed shells, all above 6.5 mm small shell-diameter).

Among Recent species *M. corrugata* seems close to *M. germaini* Pallary (1939, Pl. 6, Figs 5–8; 14) from Syria (Nahr e Sin, south of Latakia), which also has many ribs. We compared our material with 17 topotypes of *M. germaini* (in the National Museum of Wales and in the Muséum National D'Histoire Naturelle, Paris):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 28.9 mm | |
| shell-diameter (s) | up to 12.1 mm | |
| mouth-height | up o 15.4 mm | |
| shell-diameter (s) / shell-height | 0.40–0.46 | 0.44 ± 0.01 |
| mouth-height / shell-height | 0.48–0.60 | 0.54 ± 0.03 |
| mouth-height/shell-diameter (s) | 1.14–1.35 | 1.23 ± 0.07 |
| conicality | 0.66–0.82 | 0.77 ± 0.05 |
| figurativity | 0.90–0.94 | 0.92 ± 0.02 |
| shouldering | 0.78–0.84 | 0.82 ± 0.02 |
| rib number | 15– 21 | 17.40 ± 1.92 |
| rib density | 2–4.5 | 3.41 ± 0.59 |
| rib length | 3.5–4 | 3.68 ± 0.25 |
| rib curvature (right) | 0.2–0.8 mm | 0.66 ± 0.25 mm |

*M. corrugata* differs from *M. germaini* in that it is smaller and more frequently shouldered; for shells of comparable shell size (Table 1) *M. corrugata* has higher rib density and more ribs.

Among fossils, Blankenhorn (1897, Pl. 10 Fig. 6) described *Melanopsis sancta* Let., from the Pliocene of Jiser esh Shugur (Syria). The high number of ribs in this specimen suggest that it may be a synonym of *M. corrugata* (in which case the nomenclature should be adjusted accordingly), but the shell of *M. sancta* is of too poor condition to reach clear-cut conclusions.

Schutt & Ortal (1993) suggested that *M. corrugata* may have developed from a common ancestor with *M. turriformis*, but there is no considerable conchiometric similarity between these two fossil species.

From 'Ubeidiya, Tchernov (1973: Pl. 3, Fig. 2) illustrated a shell with many delicate ribs (as *M. praemorsum*); this shell is so similar to *M. corrugata* of Gesher Benot Ya'aqov that we consider it a synonym. From the Hula Valley core Moshkovitz & Magaritz (1987: Pl. 3, Fig. J) described '*M. praemorsa* Type E' as bearing fine, longitudinal sigmoid riblets (numbering about 35–40 on the last whorl). Both the high number of ribs (which they counted on the ultimate whorl, not on the penultimate whorl as we do) and the shouldered shape of their shells suggest that *M. praemorsa* Type E is a synonym of our *corrugata*.

### *Melanopsis vincta* Blanckenhorn
Fig. 3F

*Melanopsis vincta* Blanckenhorn 1897, p.115; Pl. 9 Figs 6–7.

*Diagnosis* A fossil species of the genus *Melanopsis*, *M. vincta* has a shouldered shell. In this it differs from *M. buccinoidea* Olivier, the smooth-shelled *Melanopsis* that occurs today in the Jordan River.

*Description* The shell has up to six whorls and its surface is smooth (not ribbed). The upper whorls are flat, and form a slowly expanding cone (they are usually eroded). In (the few) shells where the upper whorls are intact, they are usually ribbed. The two-three lowermost whorls are (in shells of above 6 mm small shell-diameter) almost always heavily shouldered, due to a swelling globosity of their upper part. Due to this swelling of the upper part, the lower section of each whorl is not considerably broader than the upper one (high figurativity index); and their suture is distinct. Within the aperture, the callus is so very thick that the upper part of the aperture is narrowed to a slot. The shell is dirty white, sometimes pale brown or rusty.

*Measurements*
Measurements and ratios of *M. vincta* from Gesher Benot Ya'aqov (layer GBY V–s, n=20):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 22.3 mm | |
| shell-diameter (s) | up to 9.8 mm | |
| mouth-height | up to 11.5 mm | |
| shell-diameter (s) / shell-height | 0.36–0.47 | 0.43 ± 0.03 |
| mouth-height / shell-height | 0.45–0.59 | 0.53 ± 0.04 |
| mouth-height / shell-diameter (s) | 1.07–1.58 | 1.25 ± 0.11 |
| conicality | 0.89–0.98 | 0.95 ± 0.01 |
| figurativity | 0.88–1.03 | 0.98 ± 0.03 |
| shouldering | 0.59–0.78 | 0.71 ± 0.04 |

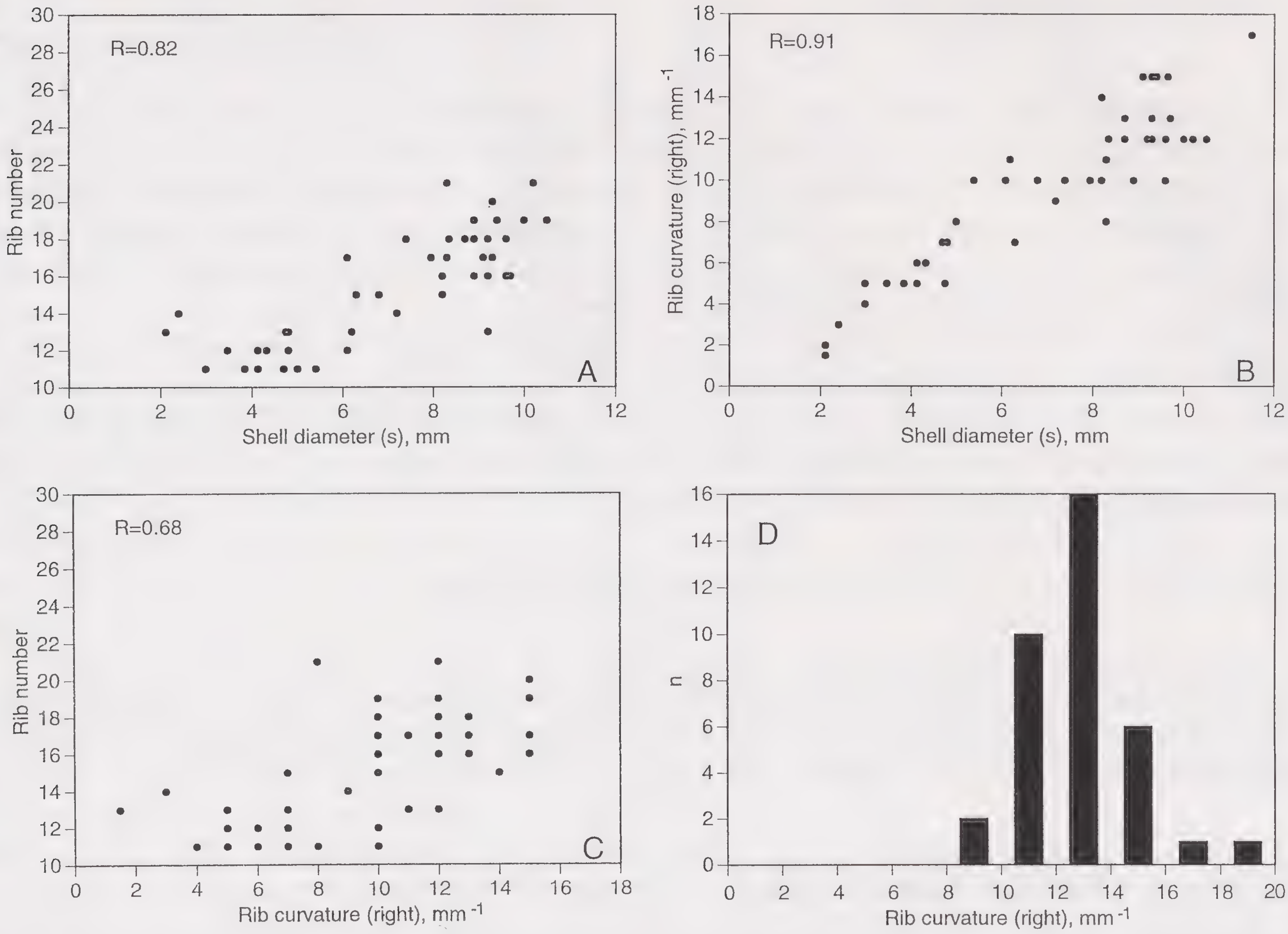

**Fig. 6** *Melanopsis sigmocorrugata* **A** Shell diameter (small) versus rib number. **B** Shell diameter (small) versus rib curvature. **C** Rib curvature versus rib number. **D** Frequency of rib curvature in shells above 6 mm shell diameter (small).

Measurements and ratios of *M. vincta* from Jisr esh Shugur (Blanckenhorn 1897; (n=4):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 14.0 mm | |
| shell-diameter (s) | up to 5.8 mm | |
| mouth-height | up to 7.2 mm | |
| shell-diameter (s) / shell-height | 0.41–0.46 | 0.43 ± 0.02 |
| mouth-height / shell-height | 0.46–0.54 | 0.50 ± 0.04 |
| mouth-height / shell-diameter (s) | 1.12–1.24 | 1.17 ± 0.05 |
| conicality | 0.89–0.98 | 0.94 ± 0.04 |
| figurativity | 1.02–1.04 | 1.02 ± 0.01 |
| shouldering | 0.71–0.80 | 0.77 ± 0.04 |

*Material* 290 specimens.

*Remarks* *M. vincta* was originally described by Blanckenhorn (1897) from the lowermost layer of Jisr esh Shugur, a Pliocene site on the left bank of the Orontes. Blanckenhorn's sample of *M. vincta* consists of 10 small shells, which have a distinct waist on the lowermost whorl (except the smallest). We measured Blanckenhorn's 4 biggest shells (Shell-height 11.1–14.0). In comparison to the Jisr esh Shugur sample the shells from Gesher Benot Ya'aqov are bigger, but their shape (shell-diameter (s) / shell-height and conicality) is very similar. In Jisr esh Shugur shells, shouldering (0.77 ± 0.04) is higher than in Gesher Benot Ya'aqov when the means are considered (0.71 0.04);

but they fall within their range.

*M. vincta* differs from other species of Gesher Benot Ya'aqov in that it is more shouldered. This difference is (almost) diagnostic when comparing *M. vincta* to *M. buccinoidea*; when comparing *M. vincta* to *M. corrugata*, this difference is not diagnostic, but it is significant (*M. vincta*: 0.71 ± 0.04, O.R. 0.59–0.78; *M. corrugata* 0.77 ± 0.05, O.R. 0.64–0.98). *M. vincta* further differs from *M. corrugata* in that it is not ribbed; however, some *M. vincta-corrugata* intermediates suggest that this character is not always reliable. As the upper whorls of *M. vincta* are ribbed (at least sometimes), in very small shells it was impossible to distinguish *M. vincta* from *M. corrugata* .

In addition to the above-mentioned 290 specimens, another 61 specimens were found that are intermediate between *M. vincta* and *M. corrugata*. They are characterized by a shell in which ribs occur but are weakly developed, or cover only part of the shell. Such intermediates were found in layer GBY V–5 only, in frequency of 2.9 % of the *M. vincta* + *M. corrugata* + intermediate specimens.

### *Melanopsis sigmocorrugata* sp. nov.
Fig. 3G

*Diagnosis* A fossil species of the genus *Melanopsis* Ferussac, 1807, *M. sigmocorrugata* differs from *corrugata* in that its ribs are more curved and less numerous, for shells of comparable size.

*Description* The shell is tall, has up to nine flat whorls, and its overall contour is almost always conic (not shouldered). The first two-three whorls are smooth. The six-seven lower whorls are covered with up to 21 narrow ribs. The ribs are curved, always to the right. Curvature, in shells of above 6 mm small shell-diameter, is almost always more than 1.0 mm. The ribs of the last whorl are less developed and well-defined than those of the upper whorls, and usually they do not reach down beyond the middle of the aperture. The suture is shallow and forms a rather regular line. The callus is weak. Many shells are pale-rusty brown.

*Measurements* Measurements and ratios of *M. sigmocorrugata* from Gesher Benot Ya'aqov (Layer GBY V–5/6 n=20):

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 24.6 mm | |
| shell-diameter (s) | up to 10.5 mm | |
| mouth-height | up to 12.5 mm | |
| shell-diameter (s) / shell-height | 0.43–0.48 | 0.45 ± 0.02 |
| mouth-height / shell-height | 0.43–0.58 | 0.52 ± 0.04 |
| mouth-height/shell-diameter(s) | 1.02–1.27 | 1.18 ± 0.07 |
| conicality | 0.78–0.91 | 0.85 ± 0.03 |
| figurativity | 0.88–0.94 | 0.91 ± 0.02 |
| shouldering | 0.79–0.86 | 0.82 ± 0.02 |
| rib number | 16–21 | 17.8 ± 1.45 |
| rib density | 4.5–6 | 5.12 ± 10.39 |
| rib length | 3–4 | 3.67 ± 0.29 |
| rib curvature (right) | 0.96–1.70 mm | 1.17 ± 0.17 mm |

*Material* 693 shells.

*Type Sample* Gesher Benot Ya'aqov layer GBY V–5/6

*Etymology* **Sigmo** refers to the sigmoid shape of the ribs; **corrugata** refers to the overall resemblance to *M. corrugata*.

*Remarks* Rib number and rib curvature increase with size (Fig. 6A, B). Sigmoid ribs may occur also in *M. corrugata*, but they are less curved than in *M. sigmocorrugata* of similar shell diameter. Thus, in shells of above 6 mm shell-diameter (s), the curve of *M. sigmocorrugata* is almost always more than 1.0 mm (Figs 6B, D; compare to Figs 5B, D). Also, in *M. sigmocorrugata* the number of ribs for a given shell diameter and for given curvature is almost always lower than in *M. corrugata* (Figs 6A, C; compare to Figs 5A, C).

Another fossil species with curvy ribs is *M. aaronsohni*, described by Blanckenhorn & Oppenheim (1927: Pl.1, Figs 14–15) from the Upper Pliocene of the mid-Jordan Valley; and by Picard (1934 pl. 8, Figs 1 –14) from fossiliferous beds near the Yarmouk outlet and from Erq el Ahmar. *M. sigmocorrugata* differs from *M. aaronsohni* in its significantly more numerous ribs (*M. aaronsohni* only 12–14 ribs for a shell with shell-height 11–13 mm, small shell-diameter 6 mm; diagnostically higher shouldering, and diagnostically higher curve height)

In the type layer (GBY V–5/6) we also found large numbers of *M. turriformis* (see below). No intermediates were found between these two species. It is noteworthy that no *M. corrugata* were found in this layer.

We are undecided as to whether 41 shells (mostly from layer II–2) should be assigned to *M. corrugata* or *M. sigmocorrugata*:

## THE *TURRIFORMIS* COMPLEX

Several *Melanopsis* of Gesher Benot Ya'aqov fall into groups that differ diagnostically (or almost diagnostically) from other species of Gesher Benot Ya'aqov. We temporarily place them within *M. turriformis* Picard, within which three ill-defined groups can be distinguished. Consequently we describe *M. turriformis,* and two additional groups.

### *Melanopsis turriformis* Picard
Fig. 3H

*Melanopsis turriformis* Picard 1934, Pl. 8, Figs. 15–27.
Not *Melanopsis turriformis turriformis* Schütt & Ortal 1993, Pl. 2 figs. 19–20.
Not *Melanopsis turiformis applanata* Schütt & Ortal 1993, Pl. 2 figs. 21–23.

*Diagnosis* A fossil species, *Melanopsis turriformis* (originally described from the Yarmouk outlet) differs from Recent *M. costata* in that it almost always has more than 13 ribs. It differs from *M. sigmocorrugata* in that it has less ribs, that are almost never curved; and from *M. corrugata* in that its ribs are more straight, less dense, in lower numbers; and in addition, usually each whorl is more conical.

*Description* The shell is tall, has up to seven flat whorls, and its overall contour is usually conic. The first two-five whorls are smooth. The three-five lower whorls are covered with (usually mildly pronounced) ribs that are almost always straight (not curved), and may reach down the entire height of the whorl. The suture is shallow and forms a rather regular line. The callus is well-pronounced. The shells sometimes have an ivory gloss (almost never pale rusty); in one single individual the shell was banded.

*Measurements* Measurements and ratios of *M. turriformis* from Gesher Benot Ya'aqov (layer GBY V–5/6, n=20):

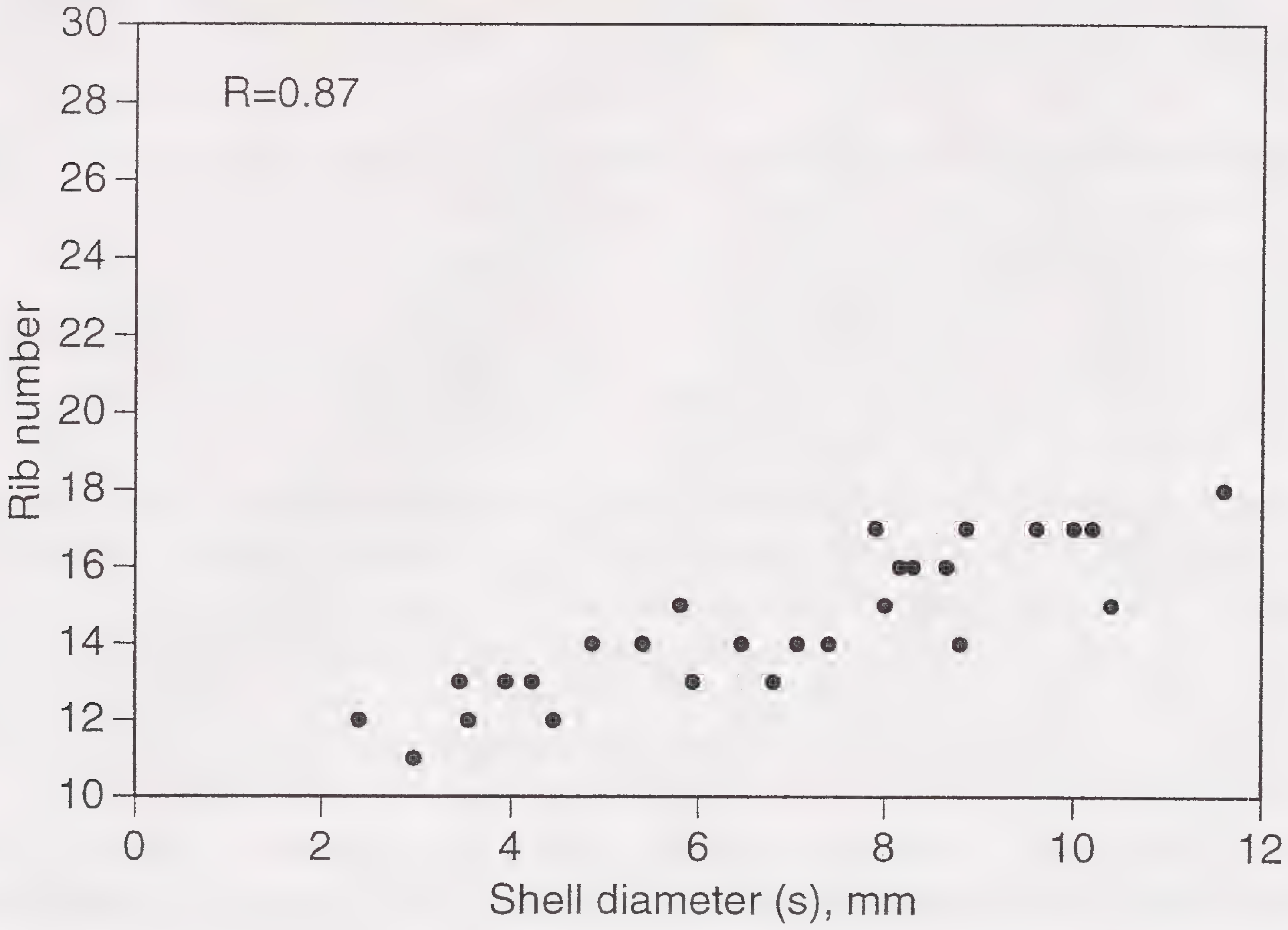

**Fig. 7** *Melanopsis turriformis* Shell diameter (small) versus rib number.

| Shell Character | Range | Mean ± SD |
|---|---|---|
| shell-height | up to 28.0 mm | |
| shell-diameter (s) | up to 11.6 mm | |
| mouth-height | upto 15.1 mm | |
| shell-diameter (s) / shell-height | 0.40–0.48 | 0.43 ± 0.02 |
| mouth-height / shell-height | 0.50–0.57 | 0.53 ± 0.02 |
| mouth-height/shell-diameter (s) | 1.12–1.37 | 1.25 ± 0.06 |
| conicality | 0.74–0.87 | 0.82 ± 0.04 |
| figurativity | 0.89–0.95 | 0.92 ± 0.02 |
| shouldering | 0.73–0.88 | 0.79 ± 0.04 |
| rib number | 14– 20 | 16.20 ± 1.82 |
| rib density | 3.0–4.5 | 3.62 ± 0.53 |
| rib length | 2–4 | 3.54 ± 0.48 |
| rib curvature (right) | 0.00–0.38 mm | 0.05 ± 0.12 mm |

*Material* 5065 shells.

*Variation* In small shells, of less than 5 mm, the penultimate whorl is not yet completely ribbed. In individuals of shell-diameter (s) = 2–3 mm the penultimate whorl is completely ribbed; eleven-twelve ribs are present. Rib number increases linearly with shell size so that the largest individual (shell-diameter (s) =11.6 mm) has eighteen ribs (Fig. 7).

*Remarks* In *M. turriformis* mean rib number is 16.20 ± 1.82 as compared to only 11.10 ± 1.08 in recent *M. costata* from the Jordan Valley (Heller *et al.*,1999); and mean rib density is 3.62 ± 0.53 as compared to only 2.55 ± 0.46. These differences are significant (t-test, $p < 0.001$). In *M. sigmocorrugata*, which occurs in some of the same layers, ribs are more numerous (17.75 ± 1.45) than in *M. turriformis*, more dense (5.12 ± 0.39) and more curved (1.17 ± 0.17 mm).

Blanckenhorn (1897: Pl. 10 Fig 6) described and illustrated *Melanopsis sancta* Let., from the Pliocene of the Orontes (Jiser esh Shugur). *M. turriformis* seems to resemble *M. sancta,* but the poor quality of Blanckenhorn's illustration does not permit a detailed comparison. We do not find *M. turriformis* among the *Melanopsis* from Gesher Benot Ya'aqov illustrated by Moshkovitz & Magaritz (1987, Fig. 3) and Schütt & Ortal (1993, Pl. 2).

In some layers shells were found that are generally smooth but with a few sparse traces of ribs. They seem intermediate between *M. buccinoidea* and *M. turriformis*. They form 0.02 % of the combined number of *M. buccinoidea* + *M. turriformis* + intermediates in layer V–5 (n=2400), 1.7 % in layer IV–7 (n=1220) and 15 % in layer II–10 (n=162).

Layer B II–2 contained 1070 shells (and layers VI–4-9 100 shells) which we tentatively assign to *M. turriformis* by their average number of ribs. However, they differ significantly from previously-described *M. turriformis* in several characteristics. We concentrate on layer B II–2 in which we recognize two ill-defined groups.

The first group ('ivory', Fig. 3I) consists of 250 shells that have dense ribs (5.65 ± 1.40) and a stepped contour (conicality = 0.86 ± 0.05; figurativity = 0.96 ± 0.01). These shells usually have an ivory gloss. They are somewhat similar to *M. costata* illustrated by Glaubrecht (1996, Pl. 25 Fig. 3) from a muddy terrace near Antakia, Turkey.

The second group ('gray-orange', Fig. 3J) consists of 900 shells that, as compared to *M. turriformis* of other layers, are significantly (t-test, P< 0.05) stouter; and their aperture larger (relative to shell height and to shell diameter). In some shells the ribs of the ultimate whorl are slightly saddle-shaped, with their mid section slightly less pronounced than the upper and lower sections. The suture is shallow, the callus is well-pronounced. The shells of this second group are usually pale grayish-orange, and banded. Measurements are given below.

*Measurements* Measurements and ratios of the gray-orange group of the *M. turriformis* complex from Gesher Benot Ya'aqov ( layer GBY II–2, n=20; all shells above 6 mm small shell-diameter).

| **Shell Character** | **Range** | **Mean ± SD** |
|---|---|---|
| shell-height | up to 16.6 mm | |
| shell-diameter (s) | up to 8.9 mm | |
| mouth-height | up to 10.8 mm | |
| shell-diameter (s) / shell-height | 0.45–0.52 | 0.48 ± 0.02 |
| mouth-height / shell-height | 0.47–0.61 | 0.56 ± 0.03 |
| mouth-height/shell-diameter(s) | 1.05–1.25 | 1.16 ± 0.06 |
| conicality | 0.72–0.98 | 0.85 ± 0.06 |
| figurativity | 0.89–1.01 | 0.95 ± 0.04 |
| shouldering | 0.69–0.87 | 0.75 ± 0.04 |
| rib number | 11 –1 9 | 14.78 ± 2.30 |
| rib density | 2.5–6.0 | 4.05 ± 0.79 |
| rib length | 2–4 | 3.48 ± 0.50 |
| rib curvature | all 0 | 0 |

*Material* 910 shells.

*Remarks* A noteworthy feature of 'gray orange' group is its considerably wide range of variation. As compared to it, the range in typical *M. turriformis* reaches only 40 % concerning rib density, 50 % concerning mouth-height / shell-height and conicality; and 75 % concerning rib number.

## CLUSTER ANALYSIS

Two dendrograms (Fig. 8), based upon conchiometric similarity, present relationships among a group of twelve *Melanopsis* taxa: the nine fossil taxa of Gesher Benot Ya'aqov and three Recent species from the Jordan Valley (*M. buccinoidea* from Berekhat HaMeshoshim, *M. costata* from Sede Nehemya, *M. saulcyi* from the Bet Shean area).

The first dendrogram (Fig. 8A) is based upon the six shell proportions (see methods) and also upon presence versus absence of ribs. Concerning the non-ribbed taxa it places Fossil and Recent *M. buccinoidea* close together, and clearly separated from *M. vincta*. Concerning the ribbed taxa, this dendrogram bears little resemblance to the taxonomy presented in the previous sections.

The second dendrogram (Fig. 8B) contains only those nine samples with ribbed shells (seven Fossil and two Recent), and is based only upon the four rib characters. It places Fossil and Recent *M. costata* close together, and *M. turriformis* typical and *M. turriformis* 'gray-orange' close together (and close to *M. costata*); *M. obediensis* and *M. saulcyi* are more distant. The most extreme position is occupied by *M. corrugata* and *M. sigmocorrugata*. This dendrogram is in accordance with the taxonomy presented in the previous section. To conclude, dendrogram 8A in part, and dendrogram 8B entirely, are in accordance with the taxonomy presented in this paper.

## DISCUSSION

The inland water system of the Levant is dominated by the north-south oriented topography of the Rift Valley. The three major rivers of the Rift, the Jordan, the Litani and the Orontes run along successive segments of the valley and create a waterway that, during the Pleistocene, was subject to water divide shifting (Por 1975). Gesher Benot Ya'aqov is within the Jordan catchment basin.

Detailed analyses of species frequencies within Gesher Benot Ya'aqov must wait for the stratigraphic analysis. Also, detailed evaluations of the Gesher Benot Ya'aqov *Melanopsis* in comparison with other sites of the Near East should best be postponed, until at least some of the species-level systematics of major Plio-Pleistocene sites of the Near East ('Ubeidiya, 'Erq el Ahmar, the Orontes) are revised. Several points are however noteworthy.

Of the seven *Melanopsis* species found at Gesher Benot Ya'aqov, two are also found in the Levant today. *M. buccinoidea* occurs in the Jordan Valley, from the tributaries of the Jordan River (Hatsbani, Banias and Dan) down to Jericho, but is absent from the Jordan River proper, the Yarmouk outlet and from Lake Kinneret (Heller *et al.*, 1999). Beyond the Jordan Valley it is found both in the Litani (Pallary 1939) and the Orontes (Pallary 1939; Schütt 1982 describes *M. ferussaci* which is closely similar and probably synonymous to *M. buccinoidea*). *M. costata*, found in riverine habitats, occurs in the Jordan Valley all along the Jordan River down to the Dead Sea, the Yarmouk outlet and Lake Kinneret. Beyond the Jordan Valley, it is found in the Orontes (Schütt 1982). These are the only two *Melanopsis* species found both at Gesher Benot Ya'aqov and at present. The other *Melanopsis* species of Gesher Benot Ya'aqov are extinct (*M. obediensis*, *M. corrugata*, *M. vincta*, *M. sigmocorrugata*, and *M. turriformis*).

It is noteworthy that among recent species of the Jordan Valley *M. saulcyi*, present up to this century in springs near the Hula, was not found at Gesher Benot Ya'aqov.

In comparing the various Pleistocene *Melanopsis* assemblages of the Jordan Valley, five of the Gesher Benot Ya'aqov species (*M. costata*, *M. obediensis*, *M. buccinoidea*, *M. corrugata*, *M. turriformis*) also occur in the mid-Pleistocene of 'Ubeidiya (as described by

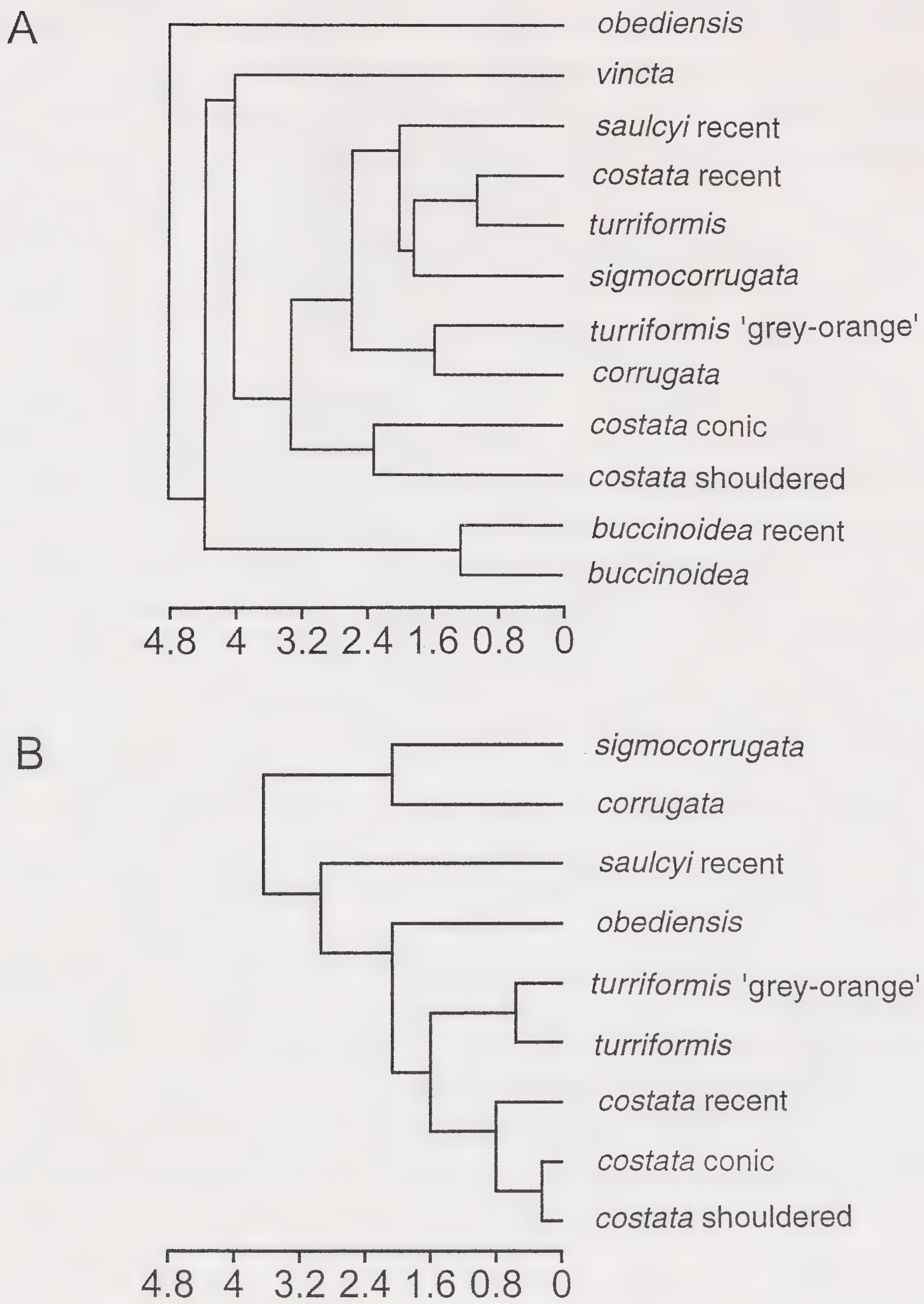

**Fig. 8** Dendrograms of Fossil and Recent *Melanopsis* taxa **A** Both smooth and ribbed taxa (9 from GBY, 3 Recent). Based upon the six shell ratios, and presence / absence of ribs. **B** Ribbed species only (7 from GBY, two Recent). Based upon the four rib characters.

Picard 1934; Tchernov 1973, who also described the *Melanopsis* of 'Ubeidiya, considered them all ecotypes of *M. praemorsa*). The malacofauna of the Early Pleistocene site of 'Erq el-Ahmar was first described in detail by Picard (1934), who mentioned six species (*M. costata noetlingi*, *M. obediensis* var. *coroniformis*, *M. aaronsohni*, *M. turriformis*, *M. cylindrata* and *M. hammamensis*). Later Tchernov (1975) suggested that five of Picard's species seem synonyms of *M. praemorsa* and that the sixth, *M. hammamensis*, is actually *M. doriae*, today endemic to Iran. Of the 'Erq el-Ahmar taxa, *M. obediensis* and *M. turriformis* were found at Gesher Benot Ya'aqov whereas *M. doriae* was not found.

Beyond the Jordan Valley, three species of Gesher Benot Ya'aqov (*M. buccinoidea*, *M. costata*, *M. vincta*) occur also in the Plio-Pleistocene of the Orontes (as described by Blanckenhorn 1897 and Blankenhorn & Oppenheim 1927). The possibility that already during the Upper Pliocene and Lower Pleistocene the fauna of the Jordan was largely independent of the Orontes was first suggested by Picard (1934) and later by Tchernov (in Schütt & Ortal 1993). The Gesher Benot Ya'aqov *Melanopsis* give these suggestions a quantitative basis, of 43 % similarity — a rather high percentage that weakens arguments as though the fauna of the Jordan was largely independent of the Orontes. Further, whereas *M. buccinoidea* and *M. costata* were present throughout all Gesher Benot Ya'aqov layers (more-or-less) *M. vincta* appeared only in the uppermost layer (GBY V–5). Therefore one reasonable period for extensive faunal connections between the Jordan on the one hand and the Orontes-Litani catchment areas on the other, might have been during GBY V-5 of Gesher Benot Ya'aqov. (Rosenthal *et al*. 1989, who investigated the isotopic composition of fossil *Melanopsis* shells from Gesher Benot Ya'aqov, suggested that the Litani may have once flowed into the Hula.) To conclude, the Gesher Benot Ya'aqov *Melanopsis* assemblage is more similar to that of 'Ubeidiya than to any other currently known fossil assemblage.

Among recent *Melanopsis* of the Jordan Valley, smooth-shelled *buccinoidea* and costate-shelled *M. costata* remain distinct but in zones of contact (as in stream outlets into lakes) smooth-costate intermediates may be found, though at low frequencies and over distances of no more than a few hundred m. These intermediates are hybrids (Heller *et al*., 1999; Falniowski *et al*., submitted). In fossil assemblages, intermediates between species may represent either gradual evolution from one species into another or hybridization. As evidence for gradual evolution, one would expect a sequence consisting of an ancestral taxon in deep layers, intermediate forms in transitional layers and a derived taxon in high layers. On the other hand, a sequence in which intermediates occur repeatedly would favour an interpretation of repeated hybridization.

Most shells at Gesher Benot Ya'aqov fall into clearly distinct species without much change in shape from one layer to another. Intermediates are found however, between *M. vincta* and *M. corrugata* and between *M. buccinoidea* and *M. turriformis*. The *M. vincta-corrugata* intermediates were found in one layer only, so they cannot serve to distinguish between evolutionary transition and hybridization. However *M. buccinoidea* was found in twelve layers, in nine of which also *M. turriformis* was found. The *M. buccinoidea-turriformis* intermediates were found in four layers, scattered from the beginning of the *M. buccinoidea* layers to the uppermost layer of the site. This pattern does not suggest a gradual evolutionary transition between these two species. It may suggest occasional hybridization, such as occurs today among *Melanopsis* species.

## ACKNOWLEDGEMENTS

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# *PLUTONIA SOLEMI* NEW SPECIES (GASTROPODA: VITRINIDAE: PLUTONIINAE) FROM LA PALMA (CANARY ISLANDS)

MIGUEL IBÁÑEZ[1], MARÍA R. ALONSO[1] AND MANUEL J. VALIDO[2]

*Abstract* *The new species* Plutonia solemi *is described from La Palma Island (mid-Atlantic Canary Islands). This species was known since 1878 but it was wrongly determined as* Vitrina latebasis *Mousson, 1872 by its discoverer and subsequent authors. On the basis of the type material,* V. latebasis *is considered as junior synonym of* Vitrina blauneri *Shuttleworth, 1852, a species endemic to Tenerife Island. The lectotype of* V. latebasis *is designated.*

*Key words* Plutonia solemi, *taxonomy, Gastropoda, Vitrinidae*

## INTRODUCTION

One species of Vitrinidae from La Palma Island (Canary Islands) has been known since 1878 but it still doesn't have a scientific name. This unexpected fact was due to a mistake of its discoverer, the naturalist T. Vernon Wollaston, who determined it as *Vitrina latebasis* Mousson, 1872.

Mousson (1872: 13, pl. 1 fig. 4–6) described *V. latebasis* from only with two shells, as follows:

> "T. depressa, transverse oblonga, tenuis, laevigata, substriatula, nitidissima, pallide corneo-virens. Spira plana, lubrica, summo non prominulo; sutura lineari, plana, albomarginata. Anf. 2 1/2, rapide accrescentes, depressi; ultimus ample dilatatus, ad lineam dorsalem rotundate angulatus, basi perlatus, convexiusculus. Apertura peroblicua (60° cum axi), subauriformis. Perist. simplex, acutum; margine dextro late incurvato, vix dilatato; columellari concave arcuato, lamina angusta munito, ad columellam non apertam subcallose inserto. Diam. maj. 13, min. 9.5, Alt. 6.5 Millim. Rat. apert. 4:5."

Wollaston (1878: 316) wrongly attributed to *V. latebasis* the special protoconch ornamentation of one species discovered by him and R. T. Lowe from La Palma and also the less prominent protoconch ornamentation of another species from El Hierro Island:

> "... But the character [of *V. latebasis]* by which it seems to me to be the most easily separated consists in the fact of its nucleus (or apical volutions) being always more or less sculptured with (often very conspicuous) radiating costae, which are strongly expressed in the examples from Palma, though rather less so in those from Hierro."

Following to Wollaston, Alonso *et al.* (1987) also determined the same species from La Palma as *latebasis*, as well as Gude (1896: 17), but described the species from El Hierro with the name *Insulivitrina eceroensis* Alonso & Ibáñez, 1987. We later studied the type material of *Vitrina latebasis* verifying that it is not related with the species found by Wollaston and Lowe. Because of the Wollaston's mistake, the species from La Palma remains yet without a scientific name, which is established here with the suitable diagnosis.

We also compared the type material of *V. latebasis* with that of all the Canarian Vitrinidae species, excepting *V. fasciolata* A. Férussac, 1832 (it was not found), in order to know its correct taxonomic status. The absence of the type material of *V. fasciolata* is not problematic because its presence on the Canary Islands is doubtful (Mousson, 1872; Wollaston, 1878) and its shell has 4 exclusive longitudinal fascies.

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Recently (Alonso *et al.*, in press) we showed that all the Canarian, Madeiran and known Azorean Vitrinidae belong to the genus *Plutonia* Morelet in Stabile, 1864. This genus is characterized by the autapomorphy of the distinctive course of the penial retractor muscle, rounding the right optic nerve, while the remaining Plutoniinae species have the penial retractor muscle with a normal course between its insertions, free from the right optic nerve; the penial retractor is secondarily missing in several Plutoniinae species, as *Semilimax semilimax* (J. Férussac, 1802) and *Plutonia atlantica* (Morelet, 1860). The new species here described also belongs to the genus *Plutonia.*

## TYPE MATERIAL STUDIED

The location of the type material studied of the Canarian Vitrinidae species and its geographical origin are as follows:

*Guerrina christinae* Groh, 1993, from La Gomera: Holotype (SMF 308848) and 19 paratypes (AIT/7; CGH/1; NHM/1; TFMC MT 0278/8; SMF 308849/2).

*Helicolimax lamarckii* A. Férussac, 1821, from Tenerife: Probable syntype (MNHN, Deshayes collection).

*Helix cuticula* Shuttleworth, 1852, from Tenerife and La Palma: Lectotype (from Tenerife: NMB 133, leg. Blauner, 1851).

*Insulivitrina eceroensis* Alonso & Ibáñez, 1987, from El Hierro: Holotype (AIT) and 8 paratypes (AIT/3; MNHN/1; NHM/1; NNM 55863/1; TFMC MT 0370/1; SMF 305951/2).

*Insulivitrina emmersoni* Morales, 1988, from La Gomera: Holotype (AIT) and 54 paratypes (AIT/42; ANSP 361428/1; FMNH 205915/2; MNHN/1; NHM 1986128/2; NMW.Z.2000.071.00004/2; NNM 55864/1; TFMC MT 0371/1; SMF 305954/2).

*Insulivitrina gomerensis* Alonso & Ibáñez, 1988, from La Gomera: Holotype (AIT) and 13 paratypes (AIT/10; NHM/1; TFMC MT 0226/1; SMF 305953/1).

*Insulivitrina machadoi* Ibáñez & Alonso, 1990, from Gran Canaria: Holotype (AIT) and 9 paratypes (AIT/7; TFMC MT 0372/1; SMF 308427/1).

*Insulivitrina mascaensis* Morales, 1987, from Tenerife: Holotype (AIT) and 114 paratypes (AIT/96; ANSP A18856/2; CGH/2; FMNH 205917/1; MHNG 984647/1; MNHN/1; NHM 1986130/2; NMW.Z.2000.071.00003/2; NNM 55862/1; SMF 305945/2; TFMC MT 0310/2; ZMH 2749/2).

*Insulivitrina nogalesi* Alonso & Ibáñez, 1990, from Gran Canaria: Holotype (AIT) and 48 paratypes (AIT/43; NHM/1; NNM 56226/2; TFMC MT 0373/1; SMF 308425/1).

*Insulivitrina oromii* Ibáñez & Alonso, 1988, from La Gomera: Holotype (AIT) and 34 paratypes (AIT/26; CGH/1; FMNH 205918/1; MNHN/1: NHM 1986129/1; NNM 55865/1; TFMC MT 0374/1; SMF 305955/2).

*Insulivitrina tamaranensis* Valido, 1990, from Gran Canaria: Holotype (AIT) and 231 paratypes (AIT/215; DMNH 185071/2; NHM 1988046/3; NMB/3; NMW 1988.087/1; NNM 56227/1; TFMC MT 0281/1; SMF 308426/5).

*Insulivitrina tuberculata* Ibáñez & Alonso, 1987, from Tenerife: Holotype (AIT) and 22 paratypes (AIT/17; FMNH 205919/1; MNHN/1; TFMC MT 0375/1; SMF 305946/2).

*Plutonia dianae* Valido & Alonso, 2000, from La Gomera: Holotype (AIT) and 18 paratypes (AIT/14; ANSP A18854/1; CGH/1; TFMC MT 0312/1; ZMH 2747/1).

*Plutonia falcifera* Ibáñez & Groh, 2000, from La Gomera: Holotype (AIT) and 23 paratypes (AIT/11; ANSP A18855/1; CGH/7; SMF 311979/1; TFMC MT 0311/2; ZMH 2748/1.

*Plutonia ripkeni* Alonso & Ibáñez, 2000, from La Gomera: Holotype (AIT) and 71 paratypes (AIT/42; ANSP A18853/2 and 400849/2; CGH/2; CRD/2; CRT/6; NHM/1;

NMW.Z.2000.071.00005/2; NNM 55868/1; SMF 311874/5 and 311876/2; TFMC MT 0312/2; ZMH 2746/2).

*Plutonia taburientensis* Groh & Valido, 2000, from La Palma: Holotype (AIT) and 166 paratypes (AIT/115; ANSP A18852/2; CGH/32; CGS/1; CRT/8; SMF 311875/5; TFMC MT 0314/1; ZMH 2745/2).

*Vitrina blauneri* Shuttleworth, 1852, from Tenerife: Holotype (NMB 564).

*Vitrina canariensis* Mousson, 1872, from El Hierro: Lectotype (ZMZ 500806/2, leg. Wollaston, 1870), and 2 paralectotypes (ZMZ 500806/2; ZMZ 500808, leg. Blauner, 1852, wrongly labeled from "Palma").

*Vitrina latebasis* Mousson, 1872, from Tenerife: Lectotype herein selected and a paralectotype (ZMZ 500802/2, leg. Fritsch, 1863; loc. typ.: "Palma", hic restr.: Tenerife).

*Vitrina parryi* Gude, 1896, from Gran Canaria: Holotype (FMNH 45507) and a paratype (FMNH 45508).

*Vitrina reticulata* Mousson, 1872, from Tenerife: Lectotype (ZMZ 500810/2, leg. Reiss, 1865), and 2 paralectotypes (ZMZ 500810/2; ZMZ 500811, leg. Wollaston, 1870).

## ABBREVIATIONS

| | |
|---|---|
| a | atrium |
| AIT | Alonso & Ibáñez collection, Department of Animal Biology, University of La Laguna, Tenerife, Spain |
| ANSP | Academy of Natural Sciences, Philadelphia, USA |
| ar | atrial retractor muscles |
| bc | bursa copulatrix |
| CGH | K. Groh private collection, Hackenheim, Germany |
| CGS | F. Giusti private collection, Siena, Italy |
| CRD | T. Ripken private collection, Delft, The Netherlands |
| CRT | W. Rähle private collection, Tübingen, Germany |
| CSL | F. Swinnen private collection, Lommel, Belgium |
| DMNH | Delaware Museum of Natural History, Greenville, USA |
| FMNH | Field Museum of Natural History, Chicago, USA |
| ga | glandula amatoria inside proximal vagina |
| MHNG | Muséum d'Histoire Naturelle, Genève, Switzerland |
| MNHN | Muséum National d'Histoire Naturelle, Paris, France |
| NHM | The Natural History Museum, London, UK |
| NMB | Naturhistorisches Museum, Bern, Switzerland |
| NMW | National Museum of Wales, Cardiff, UK |
| NNM | Nationaal Natuurhistorisch Museum, Leiden, The Netherlands |
| o | free oviduct |
| p | penis |
| pp | penial papilla |
| pr | penial retractor muscle |
| sp | spout |
| TFMC | Museo de Ciencias Naturales, Tenerife, Spain |
| v | distal vagina |
| vd | vas deferens |
| ZMH | Zoologisches Museum der Universität, Hamburg, Germany |
| ZMZ | Zoologisches Museum der Universität, Zürich, Switzerland |

## SYSTEMATIC DESCRIPTION

### Vitrinidae
### Plutoniinae
### Genus *Plutonia* Morelet in Stabile, 1864
Type species: *Viquesnelia atlantica* Morelet, 1860

*Definition* Plutoniinae with the autapomorphic character state. "The penial retractor muscle (starting from the penis) moves forward, forming a loop around the optic nerve, and passes below the right ommatophore retractor, then running backwards (left of the same ommatophore retractor) and ends on left side of diaphragm".

### Subgenus *Insulivitrina* Hesse, 1923
Type species: *Helicolimax lamarckii* A. Férussac, 1821

*Definition* *Plutonia* with the shell variable in shape. The animal cannot withdraw into the shell. Mantle border with well-developed mantle and shell lobes. Right shell lobe well developed, covering almost the complete shell in undisturbed conditions. Radula dichoglossan with variable marginal teeth (finger-shaped with or without ectocones, or multicuspid). Genital atrium variable in length. Penis short, with perforated penial papilla. Vas deferens entering penis apically to subapically. Glandula amatoria inside proximal vagina, usually voluminous, covered with soft tissue. Invaginated vaginal wall and spout wall entirely connected by thin connective fibres.

### ***Plutonia (Insulivitrina) solemi*** Ibáñez & Alonso, new species
Figs. 1, 2A–B, 3

*Vitrina latebasis* Mousson, 1872— Wollaston 1878: 315–316 [partim: La Palma].
*Insulivitrina latebasis* (Mousson)— Alonso, Ibáñez & Morales, 1987:63–67, figs 4, 7, 8, 13, 16–18, 23.
*Insulivitrina latebasis* (Mousson)— Morales, Ibáñez & Alonso, 1988: 166, fig. 1.

*Holotype* Collected by K. Emmerson, 18 January 1985, from Los Tilos (La Palma Island; UTM: 28RBS2687), at 650 m altitude (AIT).

*Paratypes* 202 specimens (AIT/88; CGH/83; CSL/16; NHM/2; NMW.Z.2000.071.00001 /3 alcohol + NMW.Z.2000.071.00002/2 shells; NNM 56864/5; TFMC MT 0279/1 and MT 0280/2) collected between November 1982 and February 2000, in 39 localities of the island. Furthermore, we consider as paratypes of *P. solemi* n. sp. 2 shells (ZMZ 500809, one damaged, leg. Wollaston, 1870, syntypes of *Vitrina canariensis* Mousson, 1872: wrong determination of these specimens), 6 shells (ANSP 236879/6) and 7 shells (FMNH 44502/6, leg. W. Webb and FMNH 205916/1).

*Type locality* Los Tilos (La Palma Island).

*Diagnosis* Shell slightly globular with 2½–2¾ whorls and a generally prominent apex. Protoconch ornamentation of "type V" in the classification of Ibáñez *et al.* (1987: 120–121, fig. 2), with a variable number of conspicuous radiating ribs (up to 20) and numerous wide and deep pittings, circular to irregular in shape; the pit dimensions shorten in the spaces between the ribs.

*Description* Small (up to 3 cm in length) semislugs (according to the classification of

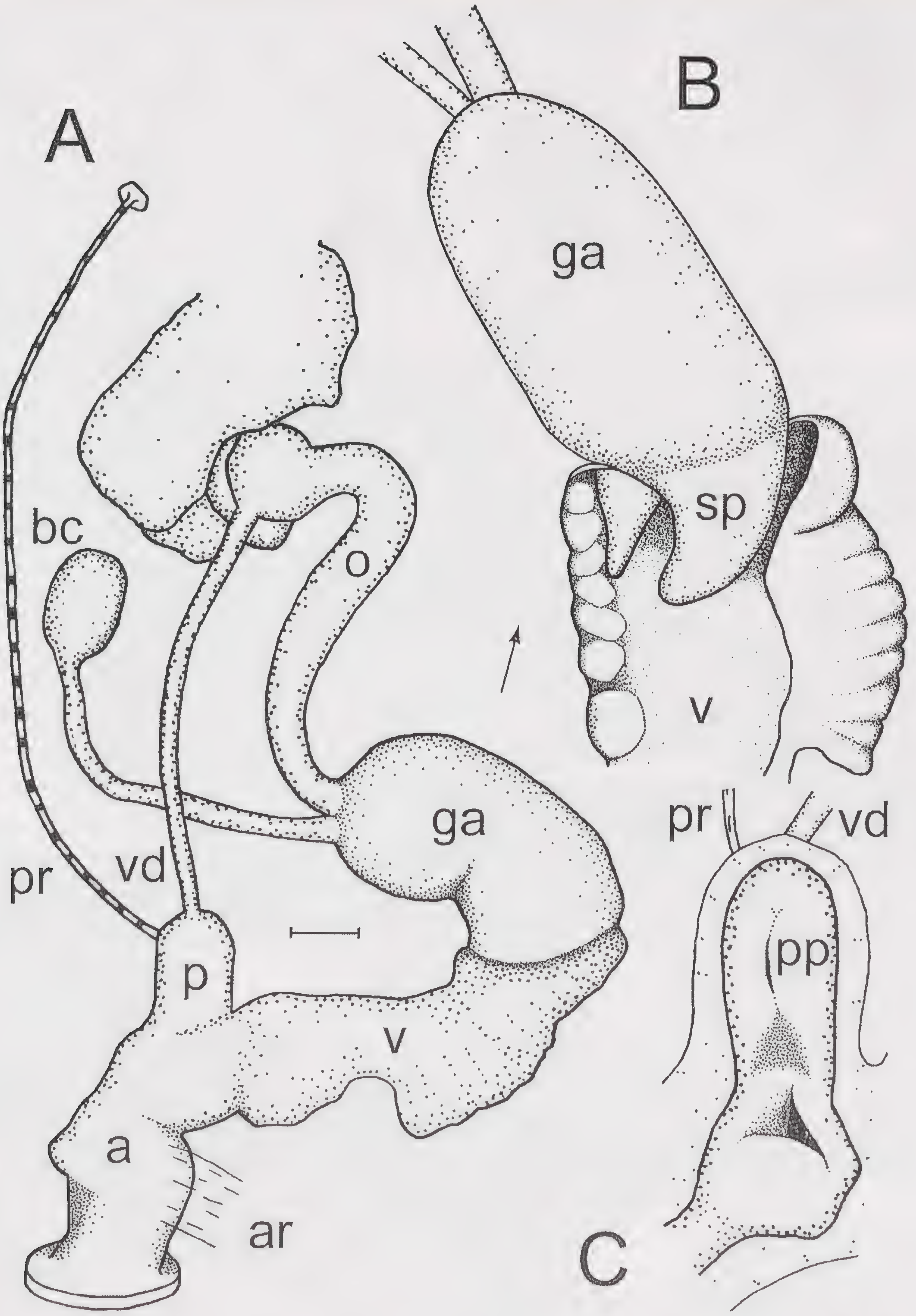

**Figure 1** *Plutonia solemi* n. sp., paratype. **A** Genital system; scale bar = 1 mm. **B** Detail of the glandula amatoria and the distal vagina. **C** Penis detail.

Tillier, 1984), brown yellowish coloured, with shell thin, greenish, translucent. Right side of mantle with a black 'lateral band' above pneumostome; this band continues for the whole border of the right shell mantle lobe (Morales *et al.*, 1988: 166, fig. 1). Sole tripartite. Foot dorsally flattened beneath the shell, bordered by a pair of distinct lateral crests extending for about half the tail length; tail tip dorsally keeled.

Radula (formula: 33M + 11L + C); marginal teeth with only one cusp.

Genital system (15 specimens dissected; the terms "proximal" and "distal" refer to the position in relation to the gonad): Genital atrium two to three times longer than the penis length, connected with adjacent part of animal integument by short atrial retractor muscles. Penis short containing a voluminous and longitudinally perforated penial papilla, which fill almost all the penial cavity. At beginning of atrium, the penial papilla extends in two folds which fuse again in one fold extending into the atrium, a deep pit remaining between the folds and the papilla itself.

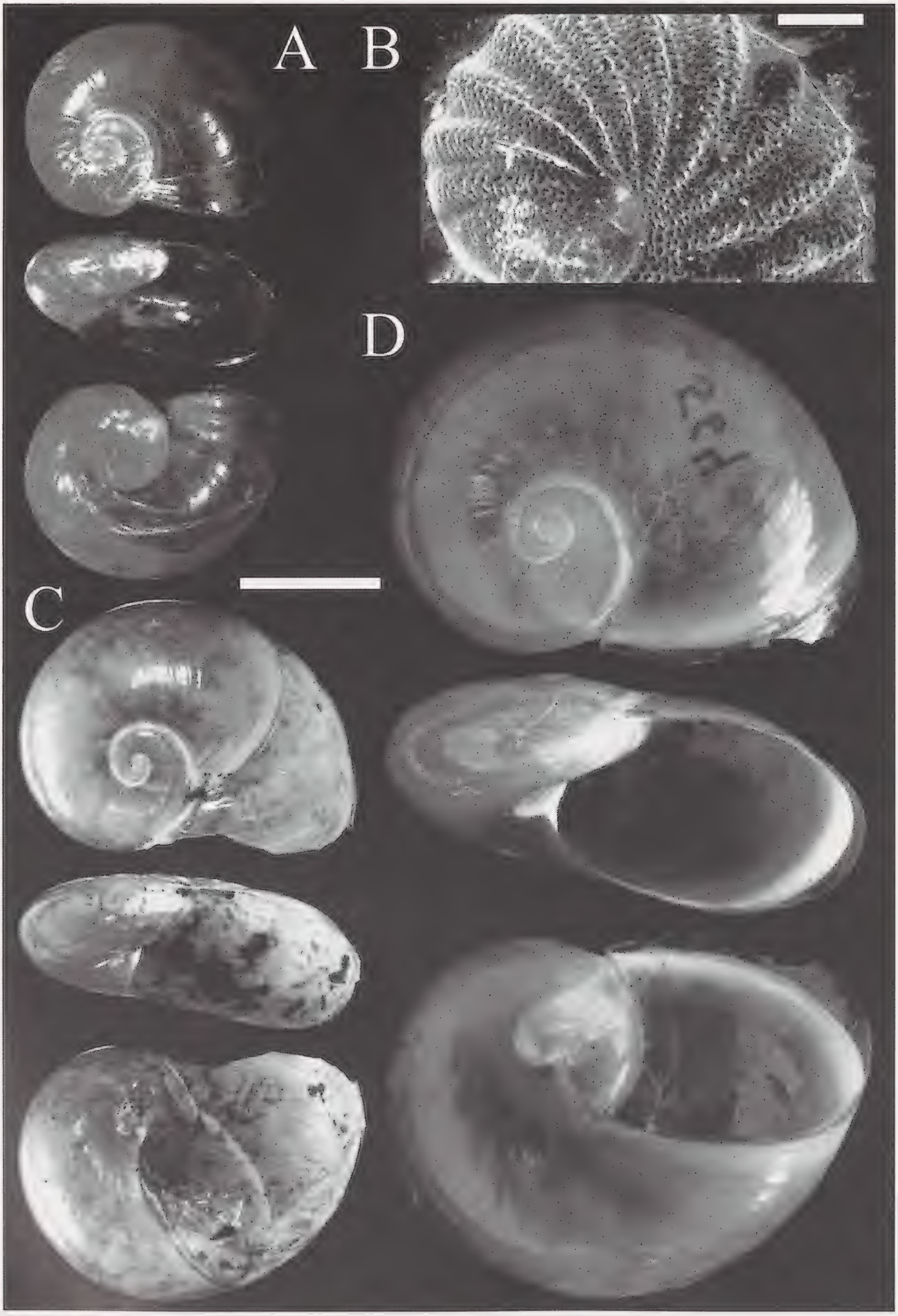

**Figure 2** **A** *Plutonia solemi* n. sp., paratype (AIT), from the Barranco de las Nieves (La Palma, at 100 m altitude; UTM: 28RBS2976). **B** *Plutonia solemi* n. sp., detail of the protoconch ornamentation. **C** *Vitrina latebasis* Mousson, 1872, lectotype (ZMZ 500802). **D** *Vitrina blauneri* Shuttleworth, 1852, holotype (NMB 564). Scale bar: A, C, D = 5 mm; B = 150 µm.

Distal vagina, free oviduct and bursa copulatrix duct similar in length and slightly longer than the glandula amatoria. Glandula amatoria covered with soft tissue, voluminous, oblong oval, with a protruding spout. Distal vagina with a longitudinal line of callosities, the more proximal bigger, protruding as a second spout.

*Derivation of name* The specific name derives from the family name of the Dr. Alan Solem (FMNH), to whom the species is dedicated in Memoriam.

*Geographic range, Habitat and Conservation* A species endemic to La Palma, where it extends in an area of about 275 km$^2$ mainly in the evergreen "laurisilva" forest but also in areas climatologically different, with pinewood and with lowland vegetation, at an altitude between 75 and 1.800 m. Conservation status proposed: "Lower Risk (Least Concern)" (LR, lc), according to the IUCN (1994, 1996) Red List categories.

*Comparisons and remarks* The protoconch ornamentation described in the diagnosis is a unique character of *P. solemi*. *P. eceroensis* is the only *Plutonia* species with the protoconch ornamentation similar to that of *P. solemi* but smoother, without ribs, only with small undulations (Alonso *et al.*, 1987: figs. 19, 20). Both species have a finger-like short penis, but that of *P. eceroensis* extends in a proximal conical protuberance in which the vas deferens inserts laterally (Alonso *et al.*, 1987: fig. 5) while the vas deferens of *P. solemi* inserts proximally in the simple penis. Both species also differ in the internal anatomy of the distal vagina: *P. eceroensis* has two longitudinal lines of callosities, while *P. solemi* only has one longitudinal line.

Moreover, the body colour is brown yellowish in *P. solemi* and greyish in *P. eceroensis*. Finally, in *P. solemi* the lateral band of the mantle's right side, above the pneumostome, is black, clearly defined, and it continues for the whole border of the right shell mantle lobe (Morales *et al.*, 1988: 166, fig. 1), while in *P. eceroensis* the lateral band is diffuse and doesn't continue in the right shell mantle lobe.

The other two *Plutonia* species from La Palma, *P. cuticula* and *P. taburientensis*, differ from *P. solemi* n. sp., besides the protoconch ornamentation, as follows: *P. cuticula* is a *Vitrina*-like helicoid snail (Ibáñez *et al.*, 1987: fig. 3; it initially was named *"Helix"* by Shuttleworth, 1852), with the shell sharply keeled at the periphery and strongly ribbed, while *P. solemi* and *P. taburientensis* are semislugs with the shell well-rounded at the periphery and almost smooth. The penis of *P. cuticula* has two small portions, and the glandula amatoria is small, spheroidal, with the proximal end covered with soft tissue arranged like a flower calyx (Ibáñez *et al.*, 1987: fig. 9), whereas the finger-like short penis of *P. solemi* doesn't have portions, and its oblong oval glandula amatoria is completely covered by a layer of soft tissue. *P. taburientensis* has the layer of soft tissue as that of *P. solemi*, but has a long penis with two portions, the proximal long and slender, with two internal parallel longitudinal structures, a torus and, opposite, a wide velum (Alonso *et al.*, in press: figs. 3A,F and 4A); also, the *P. taburientensis* body colour is whitish-beige, its lateral band is short, blackish-grey, and it is not prolonged in the right shell mantle lobe.

## THE STATUS OF *VITRINA LATEBASIS* MOUSSON, 1872
Fig. 2C

The lectotype and paralectotype of *V. latebasis* are two damaged shells (wrongly labeled from "Palma"; Fritsch, 1863). The protoconch has good condition however; it is almost smooth, with the ornamentation of "type II" in the classification of Ibáñez *et al.* (1987: 120–121, fig. 2) and without the special sculpture of *P. solemi*. Moreover, the lectotype of *V. latebasis*, with about 2¼ rapidly expanding whorls, is 1.35 times longer, 1.2 times

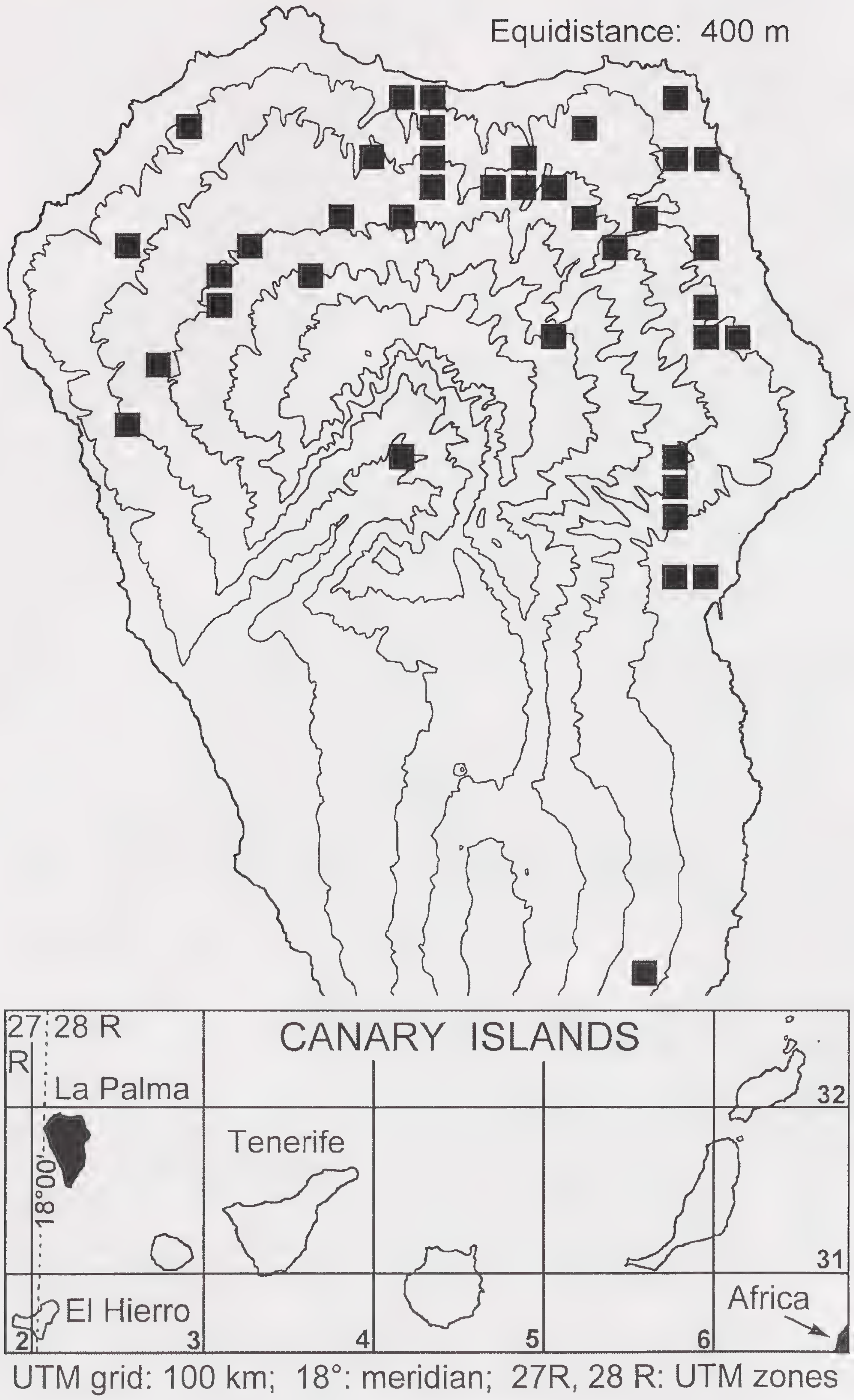

**Figure 3** Geographical distribution of *Plutonia solemi* n. sp.; the symbols represent 1 x 1 km UTM squares.

higher, more compressed and above flattened than the shell of *P. solemi*.

*V. latebasis* also differs of *P. taburientensis* and *P. cuticula*. The lectotype of *V. latebasis* is 1.4 times longer, 1.2 times higher, more compressed and flattened above than the shell of *P. taburientensis*, with about 2½ whorls (Alonso *et al.*, in press: fig. 2A) and the protoconch ornamentation of "type III" as well. The shell of *P. cuticula* (Ibáñez *et al.*, 1987: fig. 32, 38, 39; Valido *et al.*, 1993: fig. 6, holotype) is very different, helicoid, sharply keeled at the periphery and strongly ribbed.

The lectotype and paralectotype of *V. latebasis* are very similar to the holotype of *Vitrina blauneri* (Fig. 2D), a species endemic to Tenerife, and we confirmed that the three shells belong to the same species. Because of this, *Vitrina latebasis* Mousson, 1872 is a junior synonym of *Vitrina blauneri* Shuttleworth, 1852.

## ACKNOWLEDGMENTS

Our special thanks go to Mrs Trudi Meier (ZMZ) and Dra. Margret Gosteli (NMB), for loaning us the type material of *Vitrina latebasis* and *V. blauneri*, respectively.

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# REVISION OF THE GENUS *PARABORNIA* (BIVALVIA: GALEOMMATOIDEA: GALEOMMATIDAE) FROM THE WESTERN ATLANTIC, WITH DESCRIPTION OF A NEW SPECIES FROM BRAZIL

LUIZ RICARDO L. SIMONE[1]

*Abstract* Parabornia palliopapillata *n. sp. (Galeommatidae) is described from small bivalves found attached to the abdomen of the stomatopod crustacean* Lysiosquilla scabricauda *(Lamarck) (Lysiosquillidae) from the Rio de Janeiro and São Paulo coasts, Brazil. The shell is thin, flat, white, and smooth. The hinge possesses a pair of small symmetrical cardinal teeth in each valve. The mantle border has 4 marginal folds, the third being entirely papillated, with only the umbonal region lacking papillae. The foot has a small byssus, a ventral furrow and an anterior flower-like organ. The style sac of the stomach is separated from the intestine. The incubation of ova occurs in both demibranchs. A complementary redescription of* P. squillina *Boss, 1965, the single species of the genus up to this time and associated with the same host, is provided, based on paratypes from Panama. The two species differ mainly in details of the mantle border, gill, digestive tract, anterior musculature and shape of the flower-like organ. A discussion of the family assignment of the genus is also provided.*

*Key words* Parabornia palliopapillata *n. sp,* P. squillina, *Galeommatidae, bivalvia, Brazil, anatomy, Stomatopoda.*

## INTRODUCTION

Bivalves living associated with crustaceans are frequently documented (Boss, 1965; Narchi, 1969; Abbott, 1974), including those living attached to their bodies. In the Brazilian malacofauna, however, no bivalves living on crustaceans have previously been detected. According to Abbott (1974), 40 species of galeommatids occur in the Americas, but only 2 species have been reported from Brazilian waters (Rios, 1994). Narchi (1966) described one of them, *Lepton cema* for the São Paulo coast, which is commensal with *Callichirus major* (Say, 1818) (Callianassidae). It is possible that the second species, *L. lepidum* Say, 1826, might not actually occur in Brazil.

The genus *Parabornia* Boss, 1965, encompasses up to this time a single species, *P. squillina* Boss, 1965 (type species by monotypy), with a geographic distribution from western Florida to Panama (Abbott, 1974). This species is found associated with the stomatopod crustacean *Lysiosquilla scabricauda* (Lamarck, 1818) (Lysiosquillidae).

At the Museu de Zoologia da Universidade de São Paulo (MZSP), carcinologists discovered small bivalves attached to the abdomen of *L. scabricauda* collected from southeastern Brazilian coast. An analysis of the material preliminarily identified the bivalves as *P. squillina*. However, comparison with paratype specimens of that species showed that, despite the close similarity of the shell and the same host habitat, sufficient anatomical differences exist to consider the Brazilian material as a different species. Although the original description of *L. squillina* is quite complete, including some anatomical aspects, a more complete description of this species is necessary, and is provided herein, emphasizing the differences between the two species.

The systematic arrangement of the Galeommatidae has been relatively unstable, with some taxa of the family sometimes placed in other families (compare, e.g., the classification given by Abbott, 1974, with that of Moore, 1969), a problem reviewed by Ponder (1971a, 1998). Taxonomic problems within the superfamily Galeommatoidea have been

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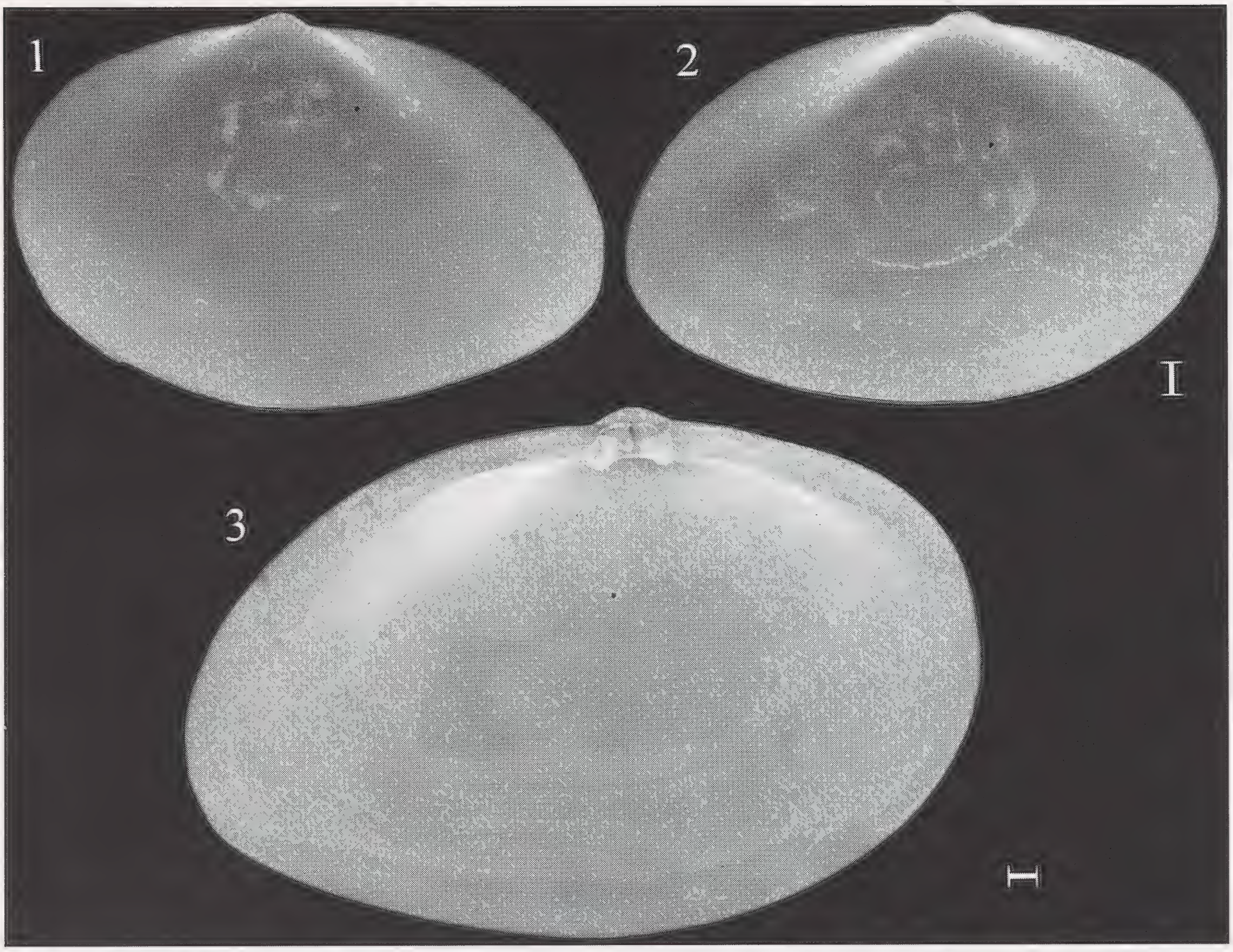


**Figs 1–3** *Parabornia palliopapillata*, shell scanning electron micrographs (MZSP 32192). **1–2** left and right valves, outer view. Scale bar = 300 µm **3** left valve, inner view. Scale bar = 200 µm.

clarified by some phylogenies, such as that of Bieler & Mikkelsen (1992). In this paper, the systematics of Ponder (1998) is followed.

## MATERIAL AND METHODS

All bivalve specimens received for study were already separated from their crustacean hosts, so details of the life habits were not fully available. However, some young specimens have subsequently been seen still attached to the host and some additional information was obtained from the carcinologists. Some specimens had inexplicably decalcified shells, with only a thin periostracum and remains of the calcareous layers present. The paratypic lot of *P. squillina* is preserved in 70% ethanol; 3 of the specimens had already been extracted from the shell and dissected. They were extracted from the shells and dissected by usual techniques and immersed in 70% ethanol under a stereomicroscope. All drawings were done with the aid of a camera lucida. Scanning electron micrographs of the shells were produced in the Microscopy Laboratory of the Museu de Zoologia da Universidade de São Paulo.

Abbreviations of institutions: AMNH: American Museum of Natural History, New York, NY, USA; MZSP: Museu de Zoologia da Universidade de São Paulo, Brazil.

## SYSTEMATICS

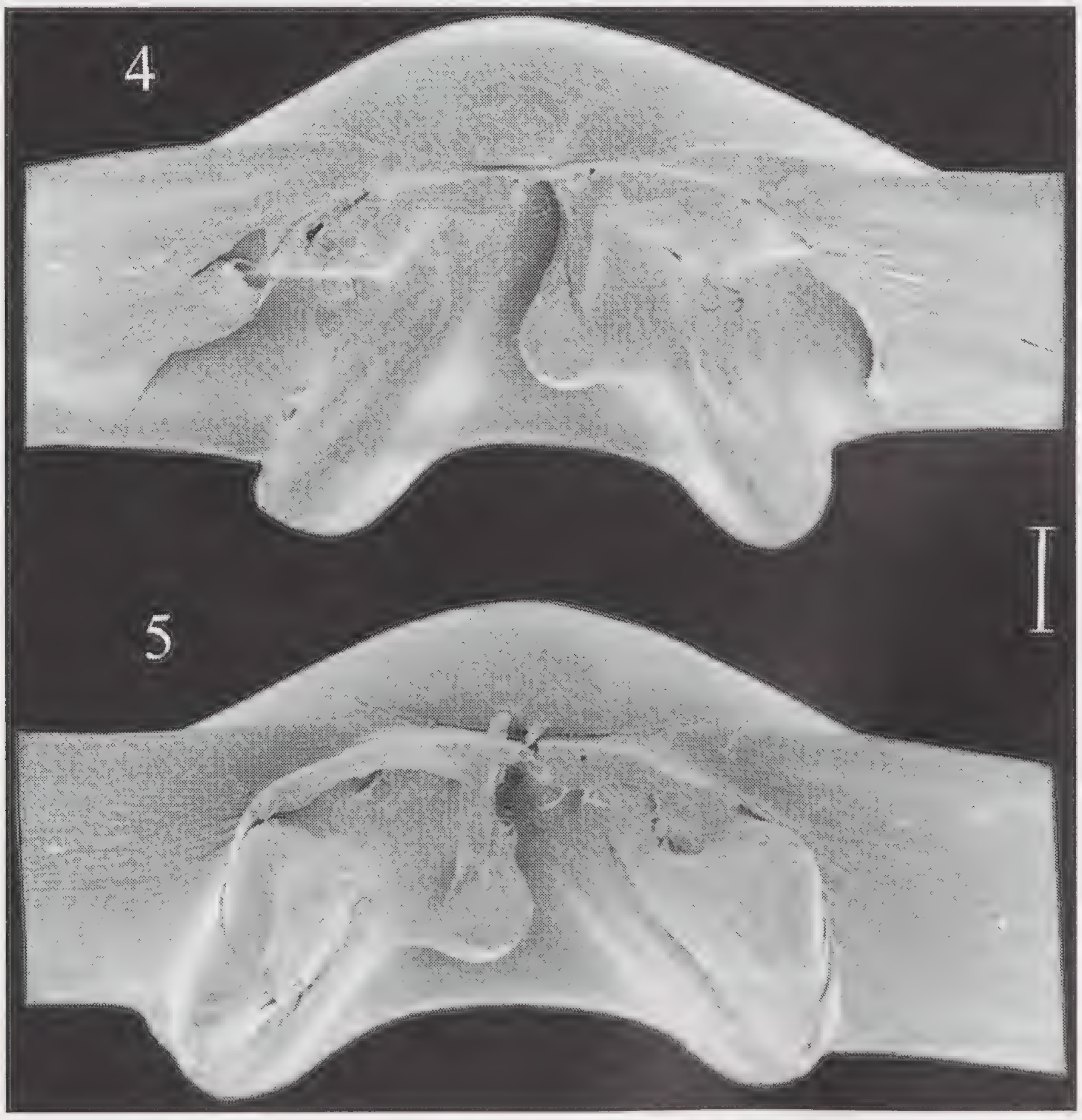
### *Parabornia palliopapillata* new species Figs 1–13

*Holotype* MZSP 30083 from type locality. Measurements in mm: 7.1 by 5.2 by 1.7 (respectively antero-posterior length, dorsa-ventral height, lateral width).

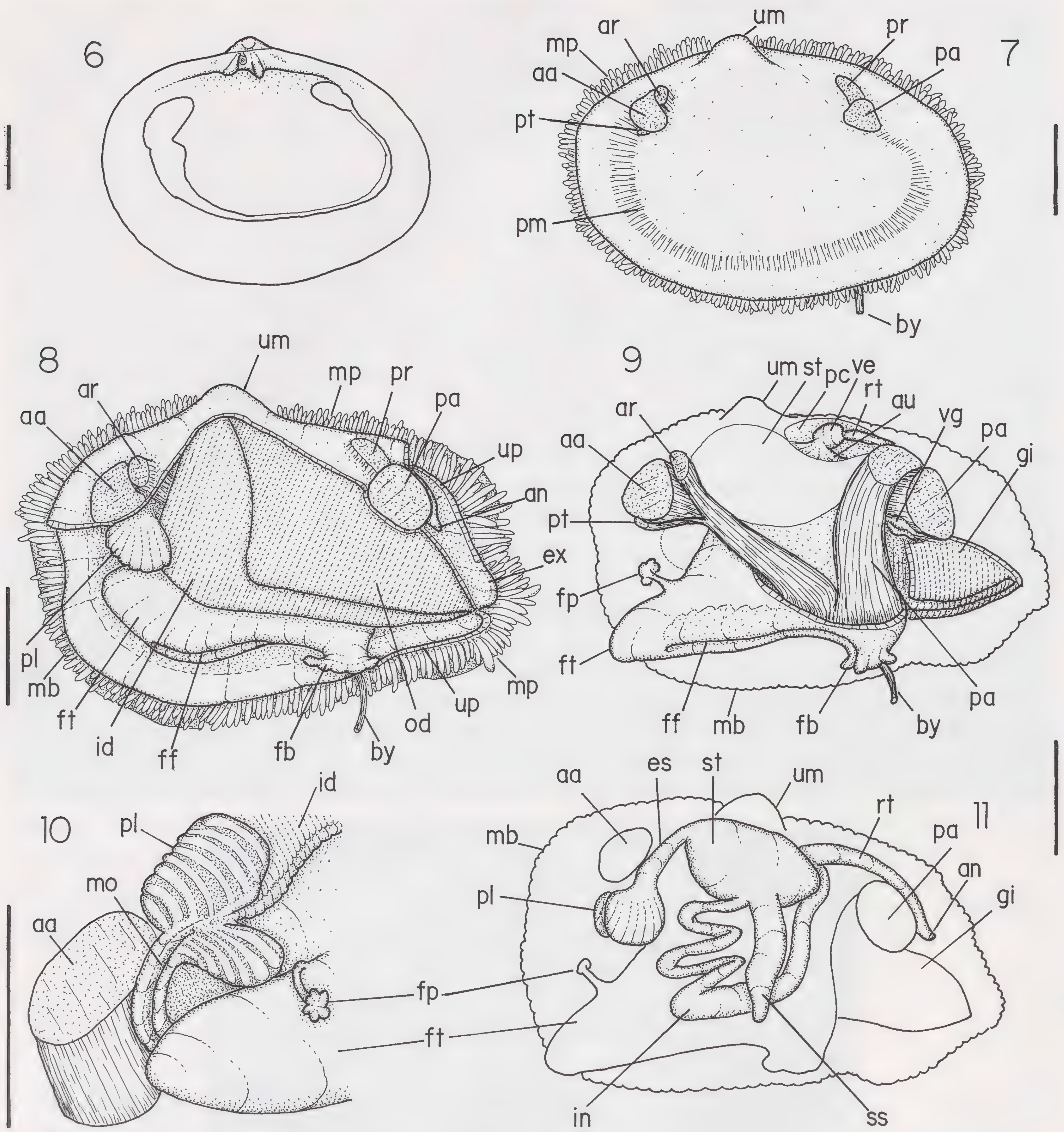
*Paratypes* BRAZIL. Rio de Janeiro; Ilha Grande, MZSP 30081, 1 specimen, MZSP 32191, 2 young specimens (E. Garbe coll., 1905). São Paulo; Ubatuba, MZSP 30086, 3 specimens with decalcified shells (1983); São Sebastiao, MZSP 30082, 2 specimens with decalcified shells + 1 shell (E. Garbe coll., 1915), MZSP 30084, 3 specimens with decalcified shells (C. M. Silva coll.), Canal, MZSP 32189, 4 young decalcified specimens (M. Silvio col., 7/xi/1959), Buzios Island, MZSP 32187, 1 young specimen (A. Begossi col., xii/1986), Alcatrazes Island (Instituto de Pesca col.), MZSP 32184, 7 young specimens (ix/1965), MZSP 32185, 2 young specimens (v/1964), AMNH 299071, 1 specimen, MZSP 32186, 20 young specimens (iii/1964), MZSP 32192, 4 specimens (iii/1964) (measurements of figured paratype: 6.0 by 4.2 by 1.8), MZSP 32193, 6 young specimens (ix/1965); Santos, Ponta da Praia, MZSP 30085, 3 specimens (2 with decalcified shells), MZSP 32188, 6 young specimens (C. José col., 13/ii/1949), MZSP 32194, 2 young specimens (C. Jesus col.). No locality, MZSP 32190, 2 young specimens.

*Type locality* Brazil, São Paulo, São Sebastiao, Ilha dos Alcatrazes, 24°05'S, 45°42'W.

*Diagnosis* Shell subequilateral. Mantle border with 2 layers of large papillae, no anterior differentiated papillae. Flower-like organ on dorsal surface of foot with a narrow stalk. Stomach with a pair of anterior chambers preceding digestive diverticula, and a central pad edging style sac and intestinal apertures. Gastric style sac situated subterminally, long and separated from intestine.



**Figs 4–5** *Parabornia palliopapillata*, details of hinge (SEM). **4** right valve **5** left valve, note periostracum surrounding hinge and ligament between the teeth, Scale bar = 100 μm.



**Figs 6–11** *Parabornia palliopapillata*, morphology. **6** right valve, inner view, showing muscle scars. **7** outer view of a specimen extracted from shell, lateral-left view. **8** same, left pallial lobe partly removed. **9** same, further dissected to show foot, main muscles and pericardium **10** detail of anterior region, lateral-left view, palps deflected. **11** digestive tract, digestive diverticula omitted, lateral-left view. Scale bars = 1 mm. Abbreviations as in figs 12–13.

*Description* Shell (Figs 1–6). Small (< 10 mm), equivalve, laterally flattened, subequilateral, anterior slightly shorter. Color white. Outer surface smooth, glossy. Sculpture absent except for commarginal undulations and growth lines. Umbones pointed, low, small. Prodissoconch oval, about 110µm in length (Figs 4, 5). Outline almost elliptical; anterior and ventral margins rounded; ventral and posterior margins slightly produced. Hinge small, restricted to region just below umbo. A pair of small cardinal teeth in each valve (Figs 4, 5), somewhat symmetrical in sagital and frontal planes. Pair of teeth of right valve articulating with pair of teeth of left valve. Ligament (resilium) small, internal, situated between hinge teeth, shifted slightly towards dorsal and posterior. Cardinal inner space shallow. Inner surface glossy. Scars of adductor and pedal retractor muscles (described below) situated close to dorsal margin; anterior scar a little larger than posterior scar. Pallial line continuous.

Mantle edge (Figs 7, 8, 13). Entire with 4 distinct folds. Outer fold thin. Third fold consisting of 2 series of papillae, originating between the middle and inner folds (Fig. 13). Papillae long, circular in cross-section, ciliated, closely spaced, present along entire mantle border except in short hinge area. Inner folds fused in posterior ⅓ of infra-branchial chamber and in dorsal ¾ of supra-branchial chamber (Fig. 8: up). Incurrent canal along anterior and ventral region of shell edge. Excurrent canal small, just dorsal to connection of gill and edged by projections of inner folds.

Foot (Figs 8–10, 13). Of medium size. Anterior portion thick and pointed. Foot projection, or flower-like organ, situated in middle region between mouth and distal foot tip (Figs 9, 10: fp); base a slender and tall peduncle; tip a flat, circular, flower-like structure, with folded margins. Ventral edge of foot with a deep byssal groove from just behind distal tip to byssal gland. Posterior end of this furrow edged by undulating folds forming a circle, surrounding byssus fibers (Figs 8, 9: fb). Byssus gland large, white, situated in almost entire ventral region of foot around foot furrow. Byssus pale brown, generally with one or few filaments, rarely with several filaments. Hanging foot morphology, as described by Bieler & Mikkelsen (1992) for galeommatids, present.

Main muscle system (Fig. 9). Adductor muscles subequal, elliptical in section, of relatively small size. Both pairs of foot retractors large and thick, both inserting at posterior region of foot just dorsal to byssus, running dorsally, bulging into visceral mass cavity. Anterior retractor muscles running toward anterior, gradually narrowing, originating just posterior and dorsal to anterior adductor muscle in a small scar (less than ¼ of adductor area). Posterior retractor muscles running toward posterior with a somewhat uniform width along their length, originating just posterior and dorsal to posterior adductor muscle with an area equivalent to that of adductor. Paired foot protractors very narrow, almost vestigial; inserting in middle region of anterior retractor muscle, running toward anterior edging of ventral surface of anterior adductor muscle; origin very small, ventral to adductor.

Pallial cavity (Figs 8, 10, 13). Relatively large, about ⅑ of area surrounding visceralpedal mass. Ctenidia large, whitish. Gill filaments very narrow, uniform, closely packed. Outer demibranchs inserted only at their dorsal edges, dorsal to inner demibranch insertion. Inner demibranchs larger than outer demibranchs, inserted in dorsal and anterior edges to visceral sac, anterior edge inserted between palps (Fig. 10). Ventral margin of inner demibranchs with food groove. Posterior ⅓ of inner demibranch length connected ventrally with each other and ending at ventral limit of excurrent canal (Fig. 9). Some specimens with inner cavities of both demibranchs filled with ova (Fig. 13), apparently in same stage of development; outer demibranchs with larger quantity of ova.

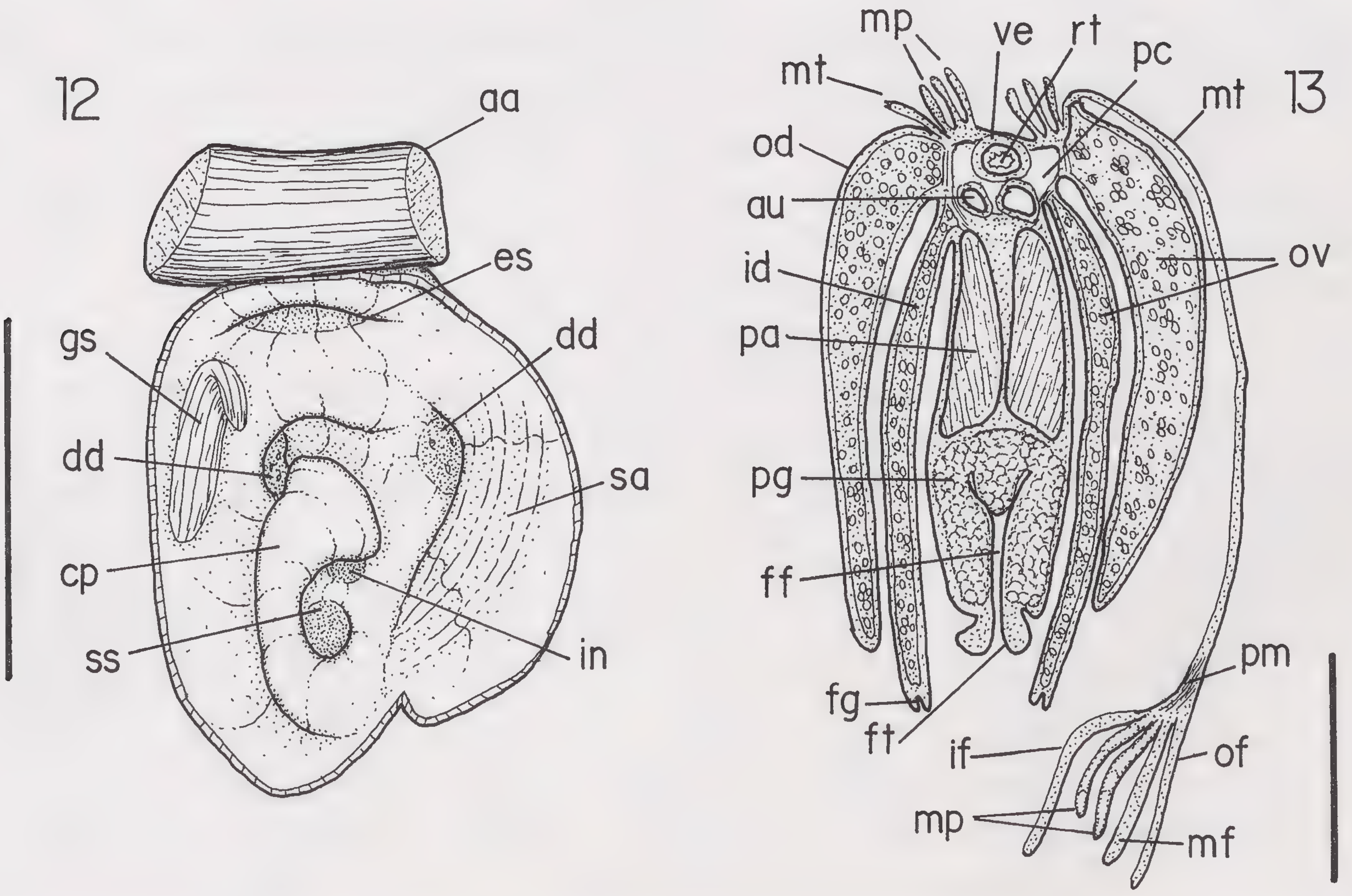
Visceral mass. Greatly compressed by retractor muscles of foot, relatively small. Large stomach dorsal. Digestive diverticula whitish, occupying a small region anterior to stomach. Gonad also whitish, occupying middle and posterior region of visceral cavity surrounding digestive tubes. (No histologic study was made for determining whether or not hermaphrodite.)

Circulatory and excretory systems (Figs 9, 13). Heart relatively small. Pericardium attached to posterior- dorsal surface of stomach. Ventricle spherical, small, surrounding intestine.

Digestive system (Fig. 11). Labial palps relatively small, outline oval, connected to anterior-ventral end of gill and adjacent region of visceral mass. Palp inner surface with few (about 8) broad folds, dorsal edges narrow, ventral edges broad and rounded (Fig.

10). Mouth broad, with thick margins, attached to anterior adductor muscle. Esophagus broad, dorso-ventrally flattened, attached to adductor muscle (Fig. 10). Esophageal inner surface with some longitudinal folds that disappear at the opening of stomach. Stomach (Fig. 12) large, ample, situated ventral to umbones. Central ventral pad curved, broader anteriorly, posterior region narrowing and disappearing. Two openings to digestive diverticula situated in each side of anterior region of ventral gastric wall, at some distance from esophageal insertion, united by a shallow transversal groove. Central pad inner curve surrounds 2 apertures: anterior aperture of intestine, posterior aperture of style sac. Gastric shield chitinous, situated in dorsal-anterior-left gastric region. Remainder of dorsal gastric inner surface with 3–4 longitudinal, low folds. Style sac relatively short (little longer than gastric height), section circular, slightly pointed at distal end. Intestine very slender, traversing 3 small loops toward ventral; third loop becoming broad, transversing dorsal foot surface, passing style sac on the right and suddenly turning dorsally; thereafter, surrounding posterior and dorsal region of stomach and running medially close to dorsal margin. Rectum attached to dorsal and posterior surface of posterior adductor muscle. Anus as a small papilla (Fig. 8) situated close to ventral surface of excurrent chamber.

Nervous system. Not observed in detail, except for a very large pair of visceral



**Figs 12–13** *Parabornia palliopapillata,* anatomy. **12** stomach, dorsal view, dorsal gastric wall sectioned at left and deflected to right. **13** transverse section in middle region of animal's body, just posterior to umbo, left mantle lobe removed. Scale bars = 1 mm. Abbreviations: aa anterior adductor muscle; an anal papilla; ar anterior pedal retractor muscle; au auricle; bg byssal gland; by byssus; cp gastric central pad; dd digestive diverticula opening; dg digestive diverticula gland; es esophagus; ex excurrent canal; fb foot region around byssus; ff foot ventral furrow; fg food groove; fp foot anterior projection (flower-like organ); ft foot; gi gill; go gonad; gs gastric shield; id inner demibranch; if inner fold of mantle; in intestine; mb mantle border; mf middle fold of mantle; mo mouth; mp mantle papillae; mt mantle, od outer demibranch; of outer fold of mantle; ov ova inside gill; pa posterior adductor muscle; pc pericardium; pg pedalbyssus gland; pl palp; pm pallial muscles; pr posterior pedal retractor muscle; pt pedal protractor muscle; rt rectum, sa gastric sorting area; sr special region of mantle border lacking papillae; ss style sac; st stomach; um umbonal region; up union (fusion) of mantle lobes by inner folds; ve ventricle; vg visceral ganglia.

ganglion situated on ventral surface of posterior adductor muscles (Fig. 9).

*Distribution* S. E. Brazil, From Ilha Grande, Rio de Janeiro to Santos, São Paulo.

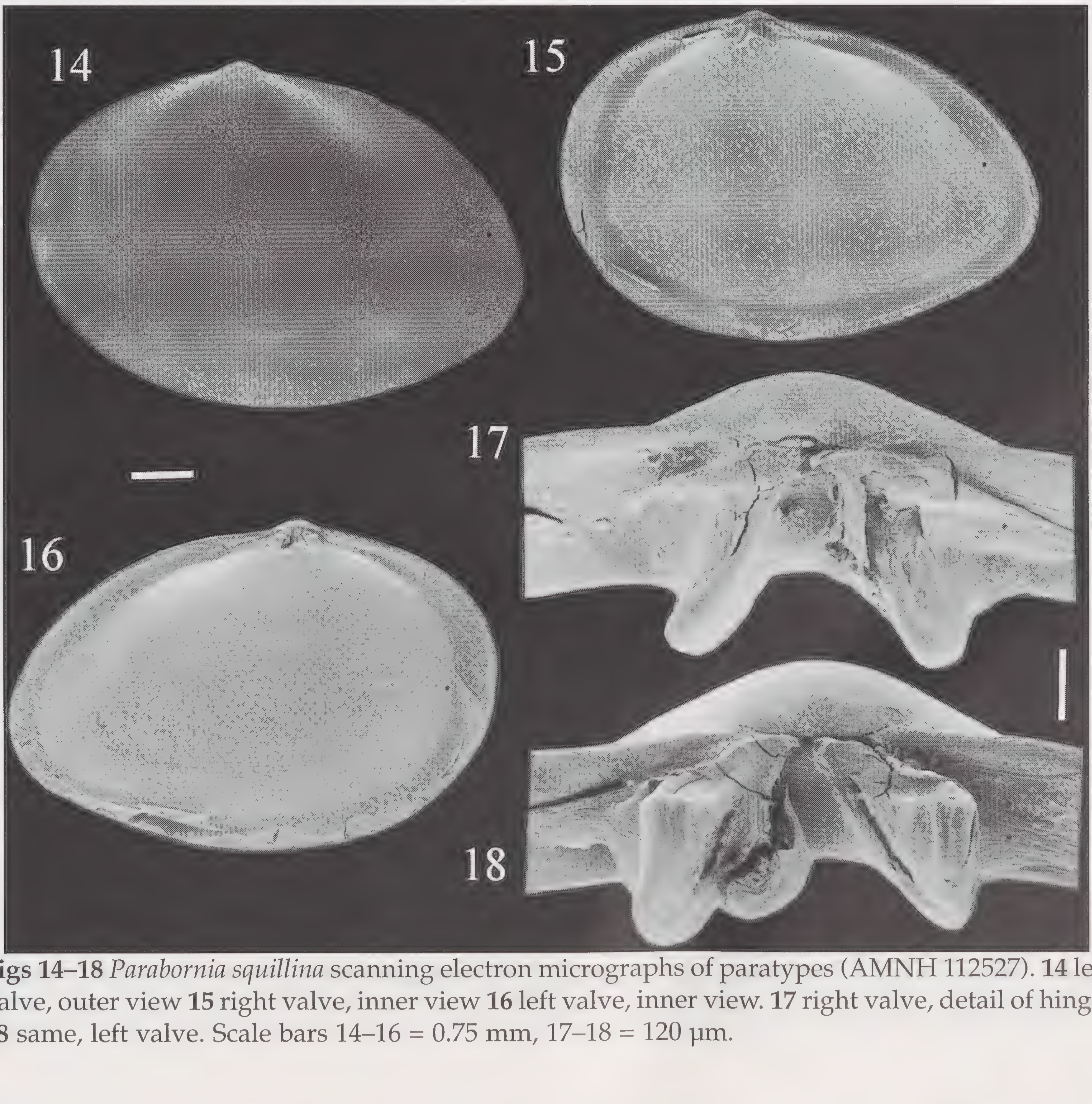
*Habitat* Attached by byssus in the ventral region of the abdomen of the crustacean *Lysiosquilla scabricauda,* on pleiopod base. Young specimens also occur on maxilipedal bases and under the carapace. Although other species of the lysiosquillids occur in the region, the studied species was found only on *L. scrabicauda.*

*Etymology* The specific epithet refers to the mantle border almost entirely papillated, from Latin *pallium* (mantle) and *papilla.*

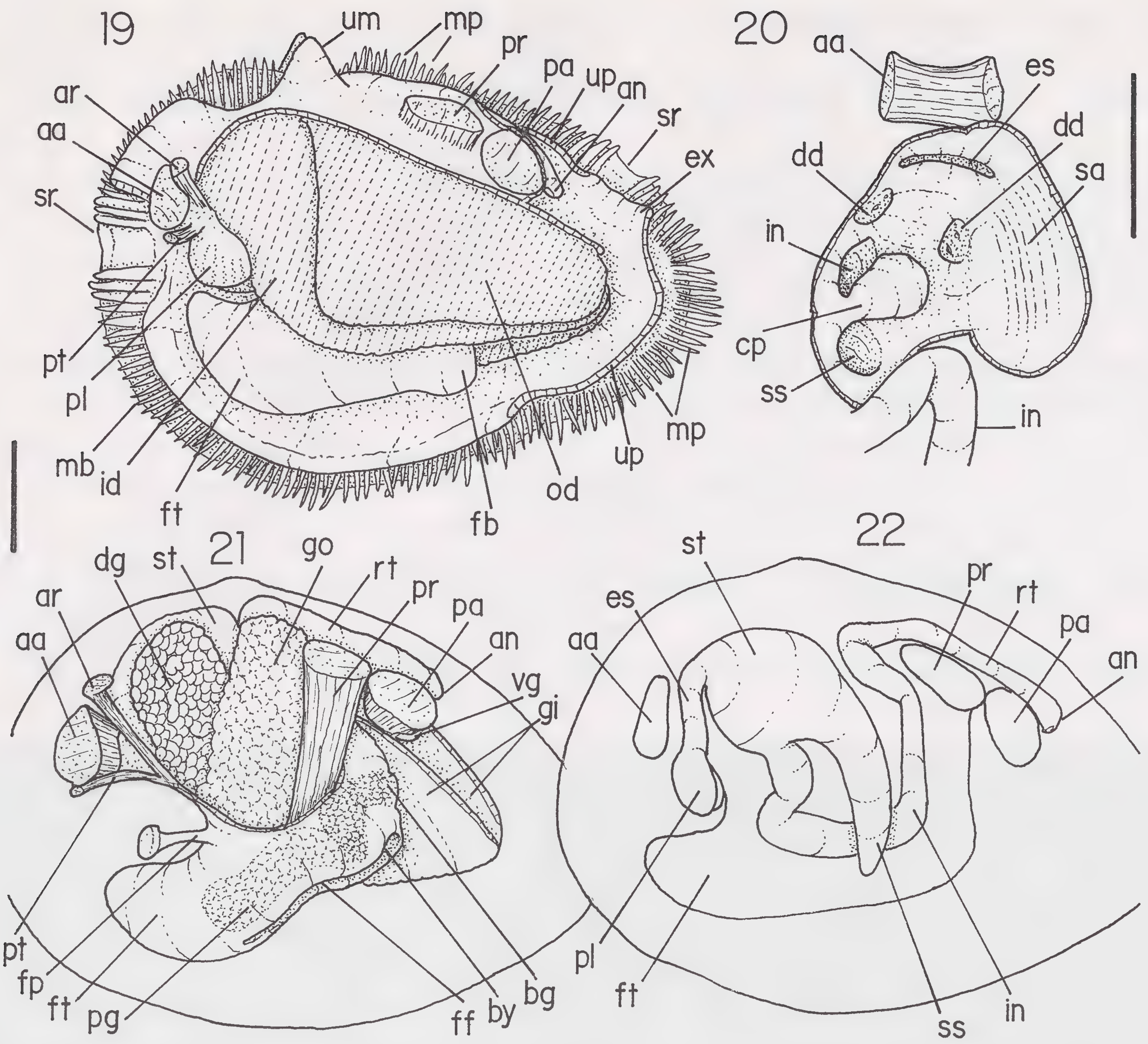
### *Parabornia squillina* Boss, 1965
(Figs 14–22)

*Parabornia squillina* Boss, 1965: 1–9 (Figs 1–3); Abbott, 1974: 469 (Fig 5415).

*Holotype* AMNH 112526 (Cristobal, Canal Zone, Panama).



**Figs 14–18** *Parabornia squillina* scanning electron micrographs of paratypes (AMNH 112527). **14** left valve, outer view **15** right valve, inner view **16** left valve, inner view. **17** right valve, detail of hinge. **18** same, left valve. Scale bars 14–16 = 0.75 mm, 17–18 = 120 µm.



**Figs 19–22** *Parabornia squillina* anatomy. **19** specimen extracted from shell, lateral-left view, left pallial lobe partly removed. **20** stomach and adjacent structures, dorsal view, gastric dorsal wall cut and deflected to right. **21** visceral mass, foot and main muscles, lateral-left view, integument covering visceral mass and all left pallial structures removed. **22** digestive tract, lateral-left view. Scale bars = 1 mm. Abbreviations as in figs 12–13.

*Paratypes* AMNH 112527; USNM 653701 (same provenance).

*Diagnosis* Shell with hinge teeth long. Mantle border possessing 2 regions without papillae, edged by large papillae. Excurrent canal with a short siphon. Flower-like organ with stalk becoming broader (conic) along its length and a tip flat and circular. Anterior foot muscles narrow. Posterior gill end free from mantle. Stomach with style sac situated terminally and central pad separating style sac from intestinal apertures. Few and broad intestinal loops.

*Comparative description* Shell. Characters closely similar to those of new species, including outline and smooth outer surface. Differs mainly by slightly more rounded outline and relatively longer pair of hinge teeth. Prodissoconch about 105µm in length.

Mantle edge. Most characters similar to those of *L. palliopapillata* including folds and regions of fusion between the lobes. Distinctive or notable features are as follows. Papillae narrower and fewer, not uniform in size (see below), occasionally bifid. Inner fold, in excurrent region, forming a short siphon, longer than that of new species and with edges far from division with infra-branchial chamber. A short region just anterior to palps with about 6 larger papillae in right lobe, and 2 larger papillae bordering a smooth area in left lobe. A similar region also found in opposed side of animal body, just posterior to excurrent siphon. A short region lacking papillae is also present close to umbones.

Foot. Features similar to those of new species, with following notable attributes. Byssal furrow of similar length, byssal and pedal glands visible through integument, separated from each other (with byssal gland posterior). Flower-like organ similarly situated and sized to that of *P. palliopapillata*, differing by gradual increase of diameter along its length (conic form); and by having apex thicker and circular (without folds).

Main muscle system. Also with similar features than those of new species, differing mainly by more slender anterior pedal muscles (protractor and retractor).

Pallial cavity. Characters similar to those of *L. palliopapillata*, with following distinctive or notable features. Gills virtually identical in form, size and disposition of filaments to those of new species, however differing in having their posterior region free from adjacent mantle wall; i.e., gills connected to each other in region posterior to foot (as in new species), separating supra- and infrabranchial chambers, but their outer edges are not connected to inner surface of mantle at about ⅐ of posterior gill length. In retracted condition supra- and infrabranchial chambers remain connected with each other at posterior end.

Visceral mass. Inner structures not as compressed as those in new species. Digestive diverticula restricted to anterior half of visceral sac, color white. Gonad occupying posterior visceral half, color pale beige.

Circulatory and excretory systems. Virtually identical to those of new species.

Digestive system. General characters similar to those of *L. palliopapillata*, with the following notable features. Stomach with style sac as terminal-posterior structure. Stomach inner surface with about same distribution of structures, except with more flattened central pad between intestinal origin and style sac aperture (and not surrounding both as in new species). Dorsal sorting area surrounding a proportionally larger and thinner gastric shield. Style sac broader and shorter, with only one loop, mainly anterior to style sac. Intestinal origin turned posteriorly (while new species runs towards anterior). Intestinal loop just posterior and dorsal to stomach crosses from left to right (contrary in relation to that of new species).

Nervous system. Same as new species.

*Measurements (in mm)* (Same parameters as in new species) AMNH 112527 (1): 6.5 by 4.7 by 2.1; (2): 6.1 by 4.3 by 1.9; (3): 6.3 by 4.5 by 2.0 (specimens labeled in lot).

*Distribution* Florida to Panama.

*Habitat* On *Lysiosquilla scabricauda.*

*Material examined* Paratypes: PANAMA; Canal Zone (Atlantic Ocean), Cristobal, AMNH 112527, 7 specimens, 2 valves (23/viii/1934).

## DISCUSSION

Indubitably *Parabornia palliopapillata* and *P. squillina* are closely related species, with very similar morphological attributes and both commensal with the same stomatopod species. On the other hand, the number and degree of differences between the specimens studied are considered sufficient for specific separation.

Of the described differences, the free portion of the posterior gill region of *P. squillina* (connected to mantle in *P. palliopapillata*), and the special arrangement of papillae in both anterior and posterior regions of mantle border (with regions lacking papillae, edged by larger papillae in *L. squillina*), are considered most significant. A small region lacking papillae is sometimes found in *P. palliopapillata*, but only in some specimens, the region is of small size, not edged by larger papillae and restricted to the anterior mantle border (never at posterior border). This feature is distinct and was consistently present in all examined specimens of *L. squillina*.

According to Gomes-Correa (1998), the common crustacean host, *Lysiosquilla scabricauda*, occurs from the Atlantic coast of the United States to Santa Catarina, Brazil. However, the *Parabornia* species show a disjuct distribution, *P. squillina* from Florida to Panama and *P. palliopapillata* from south Rio de Janeiro to south São Paulo, with a long gap between the two distributions. *Parabornia palliopapillata* has not been found on *L. scabricauda* from other Brazilian regions nor on other species of the family in a search of the MZSP collections. Several other species of Galeommatoidea occur associated with *L. scabricauda* in Florida, e.g., 5 species of *Divariscintilla* (Mikkelsen & Bieler, 1989, 1992), living detached in the crustacean's burrow.

The anatomical characters of *Parabornia* spp. are somewhat similar to those of the Brazilian species *Lepton cema* (Narchi, 1966), in having a separated gastric style sac (from the intestine), similar gill configuration, and incubation of embryos in the gill. But *Parabornia* spp. differ in having the papillae at the mantle border, a narrow style sac, and a flower-like organ on the foot. The separation of the style sac from the intestine also connects *Parabornia* to other Galeommatoidea, such as *Divariscintilla* spp. (Mikkelsen & Bieler, 1989, 1992), and *Montacutona ceriantha* Ponder, 1971b.

The projection on the foot, or flower-like organ, is a singular feature of *Parabornia* among the Galeommatidae. However something similar occurs in other species. Species of *Divariscintilla* present flower-like organs, prompting Mikkelsen & Bieler (1989) to coin this good descriptive name, situated in virtually the same foot region. However, the *Divariscintilla* flower-like organs can be multiple (in one of 5 species), and were regarded as a distinct feature of the genus (Bieler & Mikkelsen, 1992). *Pseudopythina maipoensis*, a galeommatid from Hong Kong, possesses a pair of projections in a comparable situation to flower-like organs (Morton & Scott, 1989).

Boss (1965) provided a comprehensive discussion of *Parabornia* features among the closest galeommatoidean genera. He considered the genus a member of the Erycinidae, but because present knowledge still lacks precise definitions of Galeommatoidea families, the genus *Parabornia* is here provisionally considered in Galeommatidae (sensu Ponder, 1998). Probably it belongs to the subfamily Erycininae, due to shell and internal anatomy attributes (e.g., flower-like organ, and separation of style sac).

## ACKNOWLEDGEMENTS

I especially thank Dr. Paul Valentich Scott (Santa Barbara Museum of Natural History, California) and Dr. Eugene Coan (California Academy of Sciences) for valuable review of the manuscript and comments on taxonomy. Dr. Paula Mikkelsen (AMNH) also provided detailed review of the text and discussion on taxonomy, and also facilitated loan of *Parabornia squillina* paratypes. A special acknowledgement goes to Oswaldo Campos Jr. and Dr. Gustavo A. Mello, the carcinologists of the MZSP who discovered and provided the Brazilian specimens, and Flavio D. Passos, Instituto de Biociencias da USP by suggestion of references. This study is partially supported by a governmental grant of Fundaçao de Amparo a Pesquisa do Estado de São Paulo (FAPESP) proc. # 96–6756–2.

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# ASSESSMENT OF LAND SNAIL SAMPLING EFFICACY IN THREE MEDITERRANEAN HABITAT TYPES

A. MENEZ[1]

*Abstract* *An assessment of sampling efficacy for land snails using direct searching and substratum sampling in three types of Mediterranean habitats was done at three sites in Gibraltar. The results indicate that the sites were adequately sampled after 2.5 hours of direct searching and using 4.2 litres of substratum. The applicability of the results to other sites is supported based on the analyses of diversity, species richness, number of individuals, evenness and ß diversity. The need to sample a site thoroughly by searching as many components of the habitat as possible, is illustrated using Morisita's Index of Dispersion.*

*Key words* *Sampling efficacy, land snails, Mediterranean habitats.*

## INTRODUCTION

The number of species found at a site increases with search time and area, as described by the species-area model (Brown, 1995; Hart & Horwitz, 1991; Kikkawa, 1986; Magurran, 1988; Palmer & White, 1994; Rosenzweig, 1995; Rosenzweig & Abramsky, 1993; Usher, 1991). This increase is apparent at scales ranging from quadrat sizes of less than 1m$^2$ to continental landmasses (see papers in Bell, McCoy & Mushinsky, 1991 and Ricklefs & Schluter, 1993). The habitat diversity hypothesis (Nilsson, Bengtsson & Ås, 1988; Williams, 1964) states that larger areas have more habitats, i.e. larger habitat diversity, and therefore more species, than smaller areas. Shikov (1984) used different quadrat sizes in his study of the effects of land use changes on land molluscs. Species greater than 1cm in size were estimated from 0.1x0.1m quadrats and medium sized species from 0.025x0.025m quadrats. Outeiro, Agüera & Parejo (1993) used a 0.5m$^2$ quadrat in each of their 1 km$^2$ sites. Tattersfield (1998) used fixed time, direct searching, in approximately 40x40 m (900m$^2$) plots for land mollusc collection in East African forests and Cook (1984) sampled molluscs in Madeira and the Desertas by collecting for 30 minutes at each site. Tattersfield (1990) and Wardhaugh (1996) collected until no further species were found after a 30-minute period. Nilsson *et al.* (1988) sampled carabid beetles and land snails in visually selected 10x10 m sample plots, mostly in uniform parts of major habitats.

Most land mollusc studies do not include an assessment of the time needed to find most species at a site, nor the volume of substratum needed to find most of the species contained in the substratum. The present paper reports on the assessment of sampling efficacy at three Mediterranean sites, representing three habitat types. The habitat types are: maquis (Mediterranean Steps site); man-induced (Alameda Garden site) and coastal (Talus Slope site).

## METHODS

The sites, all in Gibraltar, were categorized as to habitat type based on criteria given in Arroyo & Marañón, 1990; Rivas Goday, 1968; Rivas-Martinez, 1973, 1981, 1987; Polunin & Smythies, 1988; Polunin & Walters, 1985 and the Interpretation Manual of European Union Habitats (1995).

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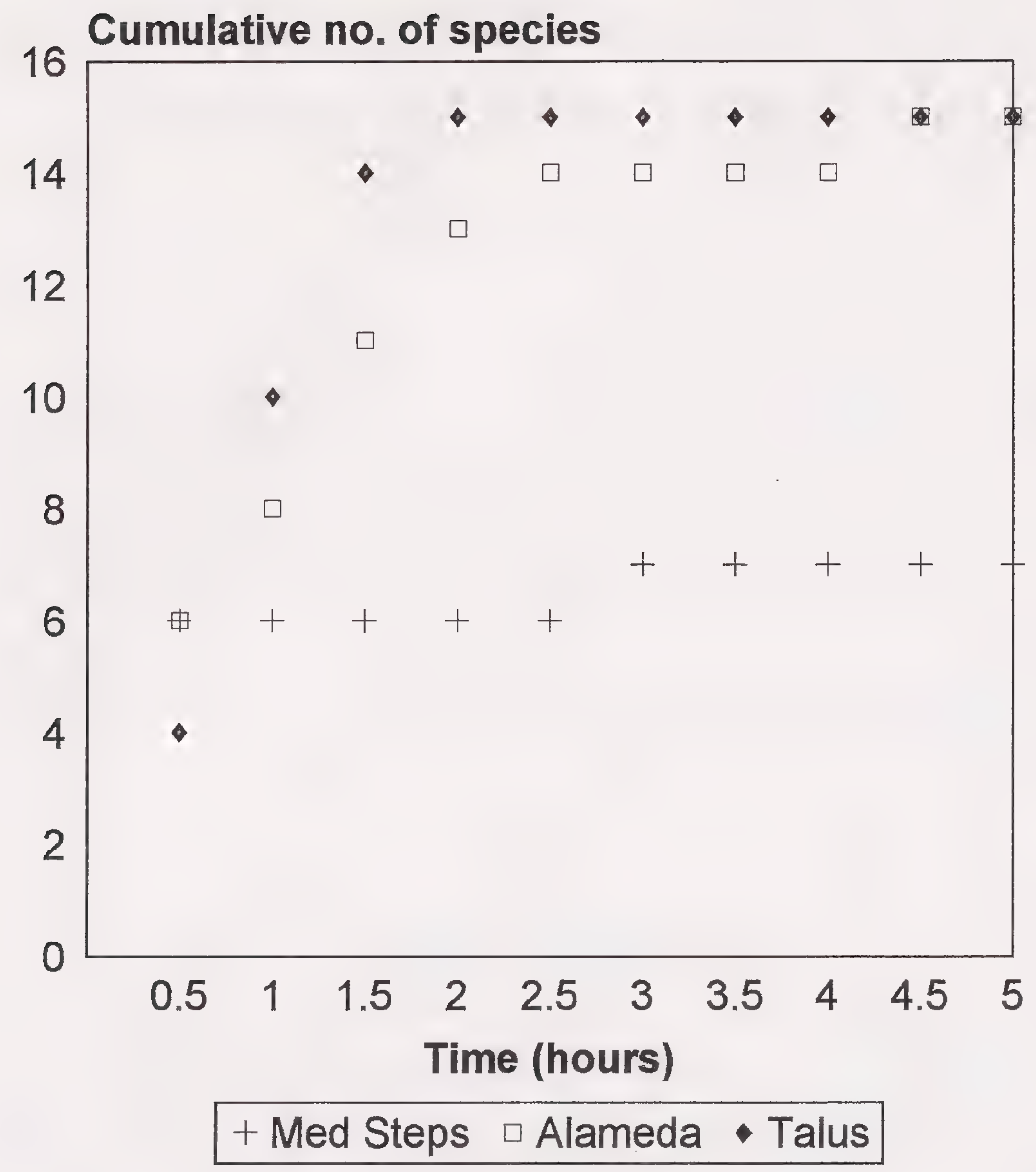

Fig. 1 Species-time relationships for the three sites

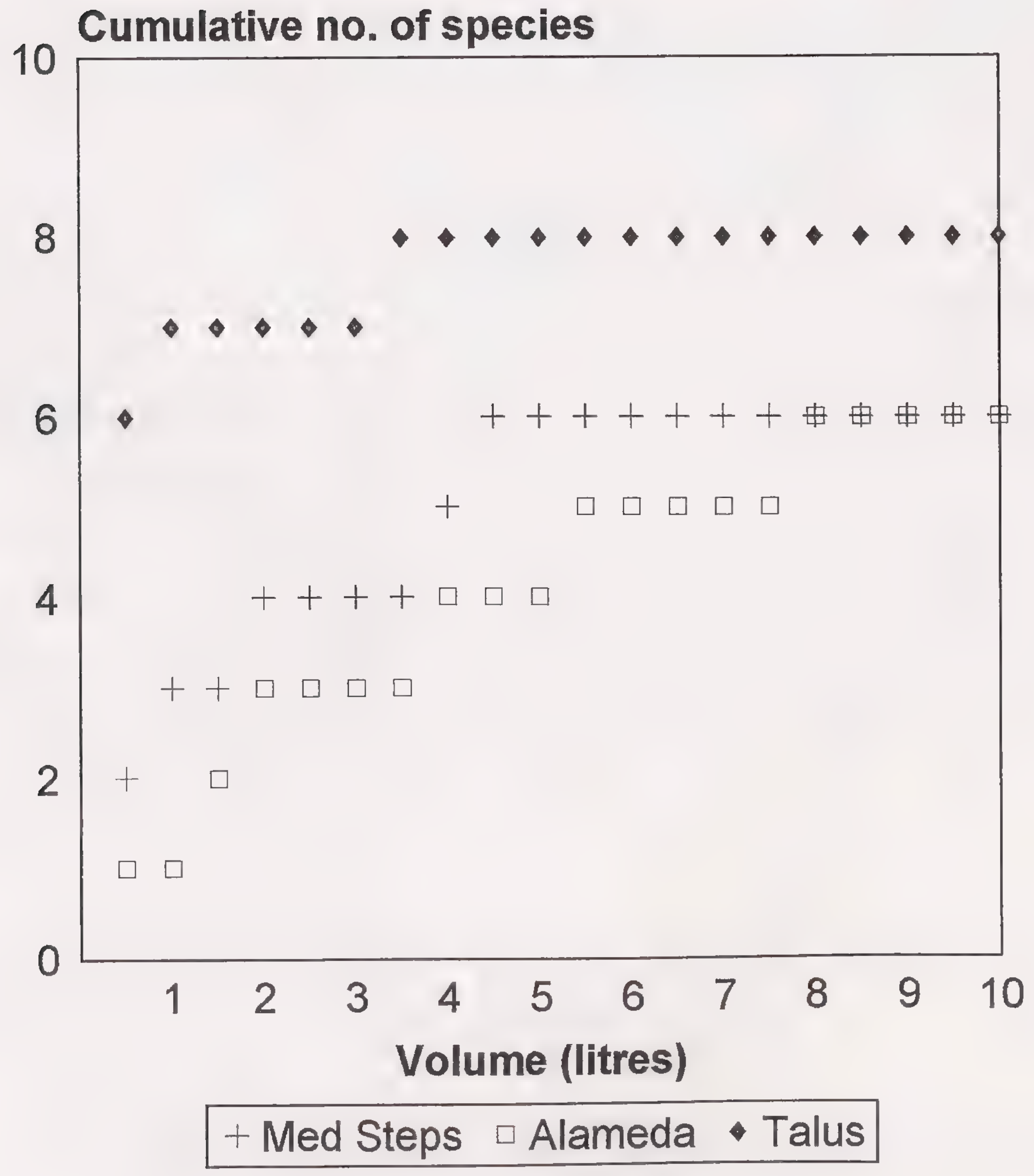

Fig. 2 Species-volume relationships for the three sites

TABLE 1

Analyses of species-abundance data. MS = Mediterranean Steps; AG = Alameda Garden; TS = Talus Slope; sam = sample point; sub = substratum; com = sample point and substratum combined; ds = 1/Simpson's diversity; S = species richness; N = total number of individuals: Heip = Heip eveness; ß = ß diversity; ld = Morisita's index of dispersion; p = p value for ld; NR = non-random dispersion (see text for further details).

| Location | ds | S | N | Heip | ß | ld | p | dispersion |
|---|---|---|---|---|---|---|---|---|
| MS sam. | 3.5 | 7 | 278 | 0.5 | 0.5 | 1.3 | 0.001 | NR |
| MS sub. | 2.3 | 6 | 28 | 0.4 | | | | |
| MS com. | 4.0 | 10 | 301 | 0.5 | | | | |
| AG sam. | 7.2 | 15 | 919 | 0.6 | 0.8 | 1.2 | 0.001 | NR |
| AG sub. | 3.1 | 6 | 28 | 0.6 | | | | |
| AG com. | 7.2 | 15 | 947 | 0.6 | | | | |
| TS sam. | 1.6 | 15 | 1510 | 0.1 | 1.3 | 1.2 | 0.001 | NR |
| TS sub. | 1.4 | 8 | 4509 | 0.1 | | | | |
| TS com. | 2.0 | 15 | 6019 | 0.1 | | | | |

### ASSESSMENT OF DIRECT SEARCH SAMPLING

At each of the sites (approximately 1x1 km$^2$) direct searching (Chater, 1998; Cook, 1984; Ramos, 1998; Tattersfield, 1990, 1998; Wardhaugh, 1996) was used to collect all molluscs (including slugs) for 30-minute periods. In all, ten consecutive 30-minute periods, representing five hours of sampling, were done at each site.

### ASSESSMENT OF SUBSTRATUM SAMPLING

To establish the amount of substratum required to collect specimens at a site, 10 litres of material were collected from a randomly selected point at each site. Each sample was thoroughly mixed and then the sample was divided into twenty 0.5 litre aliquots. Each of these was sieved through 6 mm and 2 mm meshes. The first fraction was examined by eye, the second using 5x magnification, and the third using 20x magnification, and all specimens collected.

## RESULTS

For the assessment of direct sampling the cumulative number of species was plotted against time to show species-time relationships (Fig. 1). The mean time at which the curves level off, indicating an adequate sampling time, is 2.5 hours. A similar plot was done for the assessment of substratum sampling: the cumulative number of species was plotted against substratum volume to show species-volume relationships (Fig. 2). The mean volume at which the curves level off, indicating an adequate volume for sampling, is 4.2 litres.

## DISCUSSION

Each site that is sampled should ideally be assessed for sampling efficacy. This is generally not possible because of time constraints and applicability of the findings here to other Mediterranean sites, including sites not in Gibraltar, would be desirable. The general applicability of the results obtained here is supported by further analyses of the species-abundance data. Table 1 shows the results of these analyses. The sites differ markedly in diversity. Alameda Garden (AG) has the highest diversity for the sample points (7.2) and Talus Slope (TS) the lowest (1.6). Substratum sample diversity is lower than sample points diversity at all of the sites. Species richness is similar at AG and TS, but because evenness is higher at AG (0.6) than at TS (0.1) the diversity for AG is much higher than for TS (7.2 and 2.0 respectively for sample points and substratum combined, in each case). TS has a greater number of individuals than the other sites. This is because there were large numbers of the micro-gastropod *Truncatellina cylindrica* (Férussac, 1807) at TS.

ß, a measure of differentiation diversity, indicates that the sample points at TS differ more from one another than the sample points do from one another at the other sites. This is because of the variability in number of *T. cylindrica* at the sample points at TS. The need to sample a site thoroughly, by searching as many of the components of the habitat as possible (e.g. rocks, logs, vegetation), is illustrated by Morisita's Index of Dispersion: all three sites had non-random dispersion of individuals (p values for three sites, each $<0.001$).

The results indicate that three different habitat types, with varying species richness, number of individuals, evenness, diversity, and ß diversity were sampled adequately using a search time of 2.5 hours and a substratum volume of 4.2 litres.

## ACKNOWLEDGEMENTS

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# THE ASIATIC CLAM, *CORBICULA FLUMINEA*, IN BRITAIN: CURRENT STATUS AND POTENTIAL IMPACTS

DAVID C. ALDRIDGE[1] & STEPHAN J. MÜLLER[1]

*Abstract* *The distribution and population structure of* C. fluminea *in Britain was investigated during February 2000. The presence of large individuals (32 mm length) and absence of any dead shells suggests that* C. fluminea *arrived in 1997. It now occurs in East Anglia at four sites within a 12 km radius. The greatest densities are in the River Chet, Norfolk, (up to 2500 individuals* $m^{-2}$*) where the population is dominated by small individuals (2 to 9 mm in length). The potential impacts that* C. fluminea *may have on Britain's economy and ecology are discussed.*

*Key words* Corbicula fluminea, *Britain, impacts, River Chet, non-native bivalve*

## INTRODUCTION

The Asiatic clam, *Corbicula fluminea* (Müller) is an invasive bivalve which was discovered in Britain in 1998 (Baker *et al.*, 1999; Howlett & Baker, 1999). It is native and widespread throughout Southeast Asia but its range has extended remarkably over the last century. It was first discovered in North America in 1924 (Counts, 1981) and by 1957 was abundant in many catchments within eastern and western USA (McMahon, 1983). In Europe, *C. fluminea* was first recorded from Portugal and the River Garonne in France in 1980/1981. In 1983 it was recorded in Germany's River Weser, and in 1987 the first specimens of *C. fluminea* and *C. fluviatilis* (Müller) were collected from the River Rhine. By 1991 both species were common throughout the lower and middle Rhine system (den Hartog *et al.*, 1992).

*C. fluminea* is of particular interest not only because of its ability to spread rapidly, but also because of the major impacts it can have both on aquatic ecosystems and industrial installations. Indeed, prior to the invasion of the zebra mussel, *Dreissena polymorpha* (Pallas), in North America, McMahon (1983) described *C. fluminea* as 'one of the most important molluscan pest species ever introduced into the United States'.

The aim of this paper is to document the current distribution and abundance of *C. fluminea* in Britain and to review the potential impacts that the clam's spread may have on British industry and aquatic ecosystems.

## METHODS

### LARGE SCALE DISTRIBUTION

During February 2000, rivers were sampled to record the presence or absence of *Corbicula*. At each site visited, a standard sampling technique was used: at least three *c.* 3m-long dredges were done by throwing from the bank a hand dredge with a 46x21 cm front aperture and 15 mm mesh size. Where access from the river bank was restricted dredging was done from a boat. After each dredge, the mud was washed through a 2 mm sieve and all *Corbicula* were counted. While this standard sampling technique does not allow a quantitative assessment of absolute densities of clams and is size selective with regard to the dredge mesh, it allows rapid assessment of populations and enables abundance comparisons to be made between sites.

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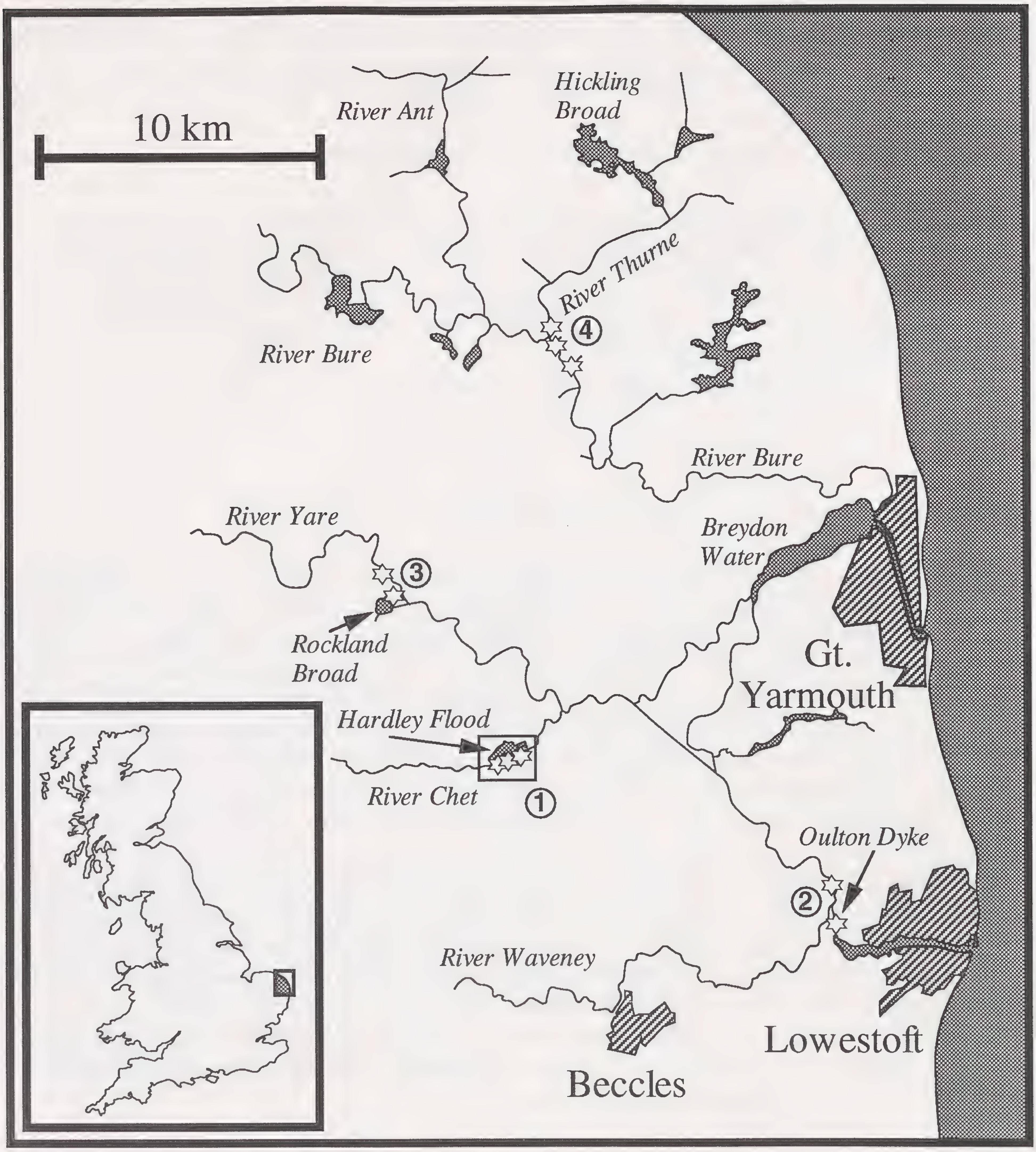

**Fig. 1** Distribution of *Corbicula fluminea* in East Anglia in February 2000. Sites where clams have been collected are represented by stars. Numbers represent the historical order in which clams were found.

**1**. River Chet population located by D. Howlett & R. Baker in October 1998 (Howlett & Baker, 1999).

**2**. Clams found in the River Waveney and Oulton Dyke by D. Aldridge & S. Müller in April 1999.

**3**. Clams found in the River Yare by S. Müller in December 1999 and Fleet Dyke by R. Baker in summer 1999 (R. Baker, pers. comm.).

**4**. Clams found in the Rivers Thurne and Bure by the Environment Agency in January 2000 (J. Stansfield, pers. comm.).

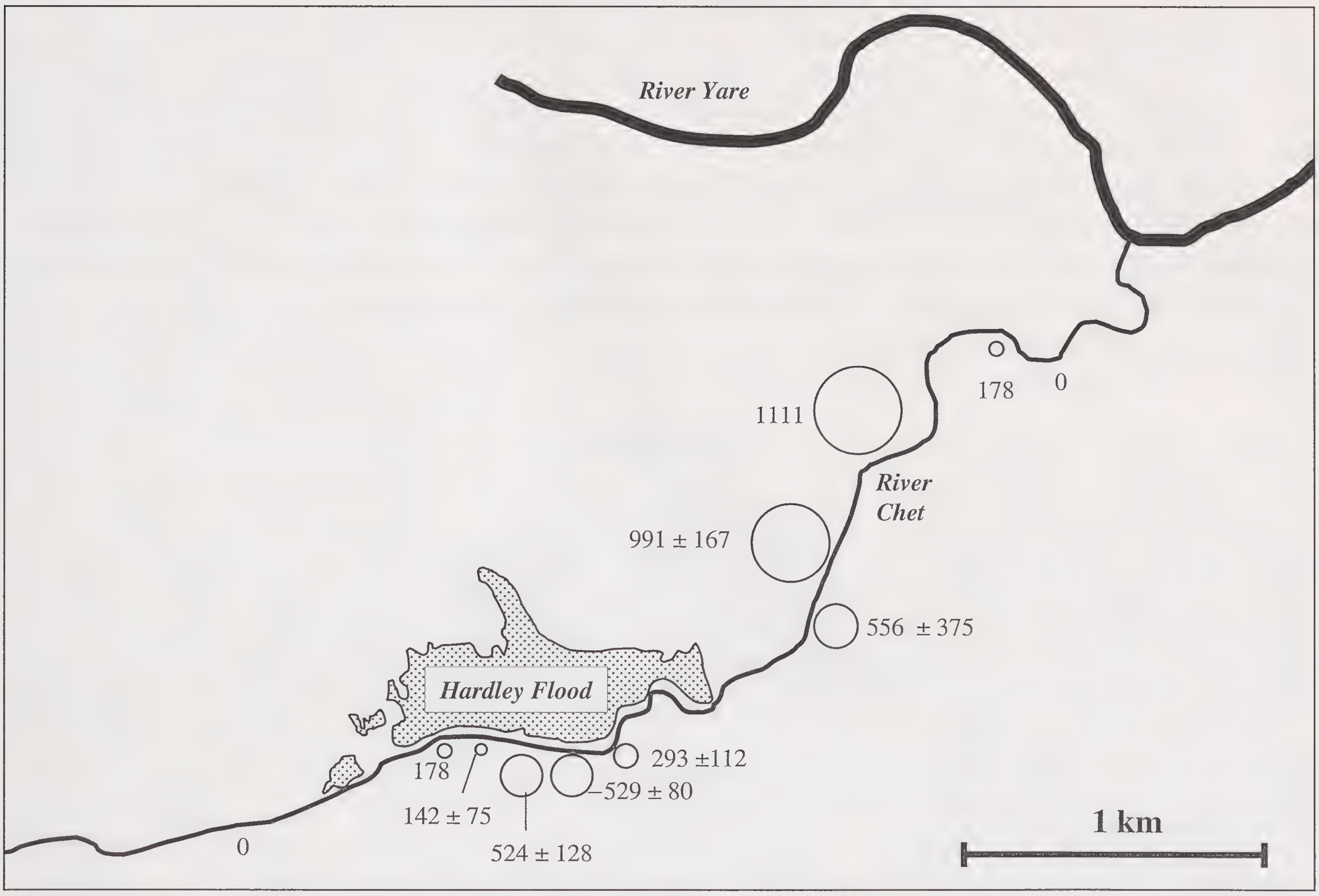

**Fig. 2** Distribution of *Corbicula fluminea* in the River Chet, Norfolk, in February 2000. Mean densities per $m^2$ are denoted by numbers in the proportionately sized circles. Standard error of the mean is given where 5 grab samples were taken at the site.

Additional data on distributions were supplied by the Environment Agency and taken from Baker *et al.* (1999).

### POPULATION SURVEYS

During February 2000 detailed population surveys were undertaken in the River Chet, which contains the greatest numbers of *Corbicula*. A total of 11 cross-channel transects were done using a van Veen grab ($0.045m^2$) from a boat. Up to 5 grabs were taken within each transect. The sediment was washed through a 2 mm sieve and the posterior-anterior length of all *Corbicula* was measured with Vernier callipers.

## RESULTS

### DISTRIBUTION OF *C. FLUMINEA* IN BRITAIN

*C. fluminea* has been recorded in four discrete regions of the Norfolk Broads, but all sites fall within a small radius of 12 km (Fig. 1). The locations range from shallow (<1 m), essentially lentic environments (e.g. Hardley Flood adjacent to the River Chet), to relatively wide (*c.* 30 m), deep (>3 m), flowing channels (e.g. River Waveney). The population in the River Chet contains the greatest densities with a mean catch per unit effort (CPUE) of 29.5 (SE ± 17.5) clams per dredge, compared with a CPUE of <1 at all the other sites.

### POPULATION STRUCTURE IN THE RIVER CHET

*C. fluminea* is distributed along a 3 km stretch of the River Chet and clams were also found in Hardley Flood in regions that connect it to the river (Fig. 2). No clams have been collected downstream of Norton Marshes or upstream of Redgrave Common. A total of 752 live *Corbicula* were collected but no dead shells were found. The population density is highest 1 km downriver of Hardley flood, where a single grab gave an estimate of 2500 individuals $m^{-2}$. The population is dominated by small (2–9 mm) individuals which appear to belong to a discrete cohort (Fig. 3). Despite the large sample size, it is unclear how many cohorts are present amongst the larger size classes.

## DISCUSSION

### C. *FLUMINEA* IN BRITAIN

The absence of dead shells in any of the sites studied suggests that *C. fluminea* is a relatively new arrival to Britain. The longest lived populations have a lifespan of 3 years in both Asia (Morton, 1977) and North America (Eng, 1979), suggesting that the species cannot have arrived in East Anglia much before 1997. It is unclear what mechanisms are important in the dispersal of *Corbicula.* It has been suggested that juvenile clams may be transported in boat bilge water or in bait buckets, while adults may be transferred by the aquarium trade or in river gravel shipped in barges (Thompson & Sparks, 1977 & references therein). Within East Anglia it is likely that pleasure boats will function as important agents of transport, especially where the anchor is dropped into sediments containing *Corbicula.* Asiatic clams can form an important part of the diet of waterfowl (Phelps, 1994) and fish such as common carp, *Cyprinus carpio* (Rinne, 1974; Morton, 1979) and these organisms may serve as important vectors. Thompson & Sparks (1977) showed that while *C. fluminea* could not survive passage through the digestive tract of lesser scaup ducks, *Aythya affinis,* the clam would survive regurgitation from the gizzard; this may enable the clams to be transported short distances over land and sea. Furthermore, Oka *et al.* (1999) found that in Japanese lakes *Corbicula japonica* could survive within the gizzards of tufted ducks, *Aythya fuligula,* and that two thirds of the ducks studied fed solely on *Corbicula.*

### POTENTIAL IMPACTS

**Economic**

*C. fluminea* has become a major pest in much of North America and Europe because of its high reproductive output, rapid growth rate, free-living juvenile stage and great powers of dispersal. All these characteristics enable *C. fluminea* to quickly invade disturbed and poorly colonised sites. *C. fluminea* has caused major problems in North America because live animals and dead shells block irrigation systems; such systems must be perenially dewatered and the clams physically removed. Of even greater concern is the ability of juvenile clams to be carried into condensers of electrical generating facilities where they attach to the walls by their mucilagenous byssus threads and ultimately grow and impede the flow of water. A number of nuclear reactors have had to be closed down temporarily in the United States so that *Corbicula* can be removed mechanically from the emergency cooling systems (Isom, 1986).

High densities of Asian clams have devastated industries in Ohio and Tennessee where river beds are dredged for sand and gravel for use as aggregation material in cement (Sinclair & Isom, 1961 in McMahon, 1983). The clams become incorporated in the cement and burrow to the surface as the cement begins to set, thus structurally weakening it.

### Ecological

The massive densities that Asiatic clam populations can reach (up to 131,000 clams m$^{-2}$; Eng, 1977) can have a major impact on freshwater ecosystems. Numerous studies have shown that the filter feeding of *C. fluminea* has led to a significant removal of suspended particulate matter from the water column. For example, Cohen *et al.* (1984) found that *Corbicula* was responsible for a major decline in phytoplankton in the Potomac River and Leff *et al.* (1990) recorded a decline in seston which was attributable to *Corbicula.* Such a decline in suspended particles has an important knock-on effect to the rest of the biota. Such system-level changes are exemplified by Phelps (1994) who showed that arrival of *Corbicula* in the Potomac River estuary led to a decline in phytoplankton, but an increase in submerged aquatic vegetation, fish populations and bird populations (particularly diving ducks that feed on molluscs).

There has been some concern in North America that *Corbicula* could lead to the decline of threatened native unionid mussels by outcompeting the unionids for habitat and food. This issue is of particular concern in Britain because rivers in Eastern England, including the River Waveney, contain internationally important populations of the depressed river mussel, *Pseudanodonta complanata* (Rossmässler) (Müller, 1999), which is a priority species for conservation on the UK Biodiversity Action Plan (BAP) (HMSO, 1996). However, no studies in North America have yet shown *Corbicula* to be directly responsible for declines in unionids (Leff *et al.*, 1990; Miller & Payne, 1994).

As well as impacting on the cycling of nutrients and organic carbon in the water column, *Corbicula* has a marked effect on organic matter dynamics in streambed sediments (Hakenkamp & Palmer, 1999). It is able to pedal-feed and thus deplete sediments of their organic content, and produces vast quantities of pseudofaeces that increase the

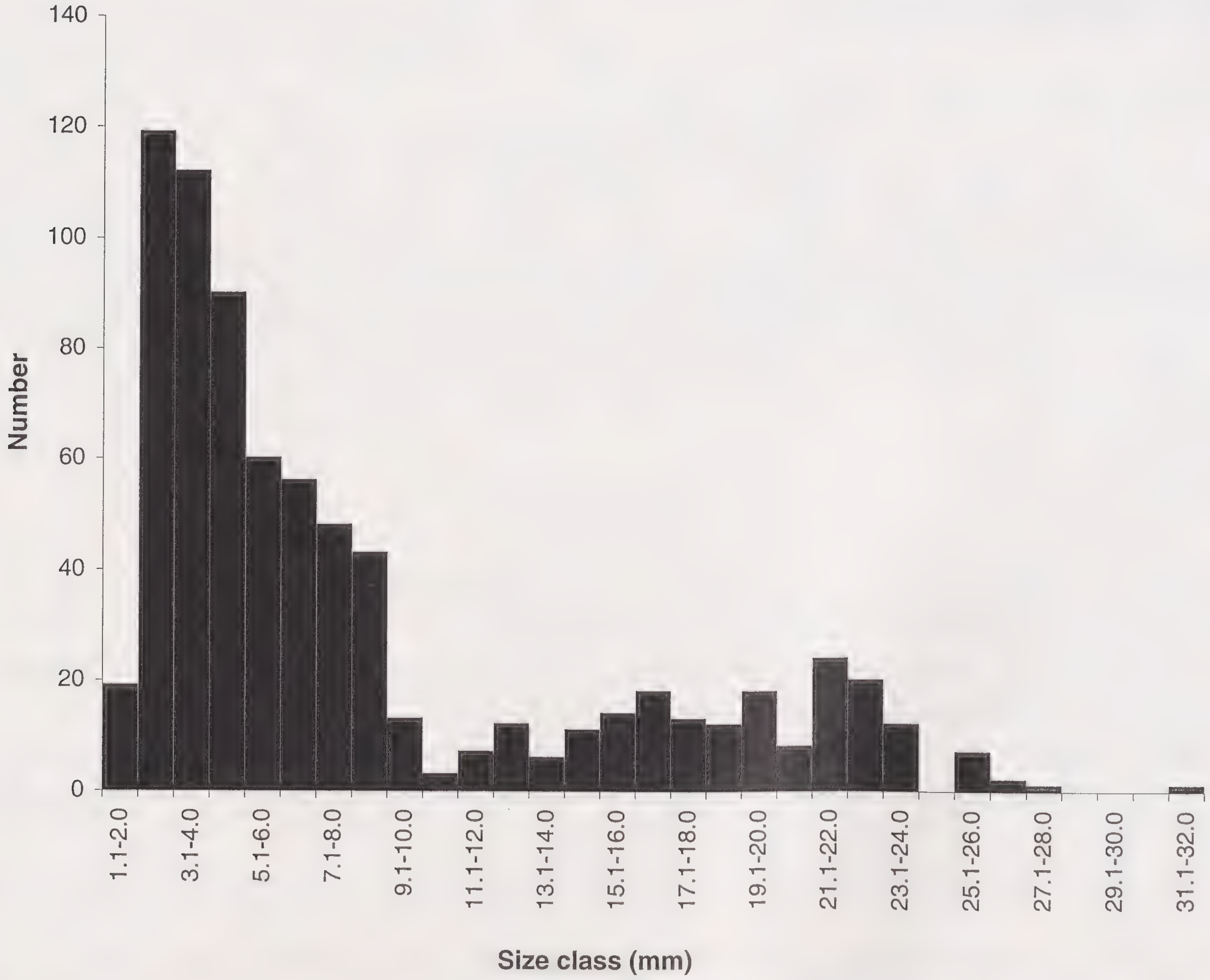

**Fig. 3** Size-frequency distribution of *Corbicula fluminea* in the River Chet in Februray 2000. Data are combined from a total of 34 grab samples along 3 km of river.

rate of sedimentation. If sedimentation rates increase in the Norfolk Broads we would predict a requirement for more regular dredging programmes to maintain flows and navigability; this would be costly and have further deleterious impacts on the river ecosystem (Aldridge, in press).

## CONCLUSIONS

Given the huge densities already recorded in the Rivers Chet, it is likely that *Corbicula* will have a major economic and ecological effect in Britain. The rapid spread of *Corbicula* in East Anglia suggests that there is little possibility that the species can be eradicated, particularly if the separate populations in Britain represent different invasion events. No species-specific techniques are available for the eradication of *Corbicula,* although biological control using crayfish (Covich *et al.*, 1981) or benthic-foraging fish (Robinson & Wellborn, 1988) may serve to control population densities. The best that can be done is to investigate ways of controlling and containing as much as possible the spread of *Corbicula.*

It is important that every effort should be made to minimise human-mediated transport of *Corbicula.* This should include efforts to wash-down boats used in research and barges used in transporting river sediments in sites known to contain *Corbicula.* Washing-down should be undertaken upstream of the lowest limit of the known *Corbicula* distribution to prevent accidental dispersal. Where equipment such as hand dredges and nets are used in surveys it is appropriate that the equipment should be thoroughly cleaned. Whilst more information is needed on appropriate methods for cleaning equipment, hot (> 50°C), chlorinated water appears to be effective (Thompson & Sparks, 1977 & pers. observ.).

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# CHANGES IN THE LAND MOLLUSC FAUNA OF THE SOUTH HAVEN PENINSULA, DORSET, BETWEEN THE 1930S AND 1999

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*Abstract* *A survey of land molluscs of the South Haven Peninsula carried out by C. Diver and C. Oldham in the 1930s was used as a basis for resurveying in 1999, albeit with different methodology. Significant changes have occurred, with a net increase in species diversity and in distributions of many species. Some of these changes are associated with parallel habitat changes both natural and anthropogenic. Only a few reflect national trends; others appear to track local changes with some time lag. Some species have not yet reached new areas of apparently suitable habitat.*

*Key words* *Land molluscs, faunal change, South Haven Peninsula.*

## INTRODUCTION

Throughout the 1930s, Cyril Diver (1892–1969) carried out a massive, interdisciplinary ecological survey of the South Haven Peninsula, Dorset, better known today as Studland Point. Diver and Good (1934) give an account of the aims and methods of the survey. It was prematurely halted by the Second World War, and rather few of its results were published. After the war, however, Diver wrote a number of papers which were never published, including one entitled “South Haven Peninsula Survey VIII: Mollusca”. This paper is 56 pages of typescript, including many tables. References to Diver (unpublished) hereafter refer to this paper. After his death in 1969, these papers, and all his notes and files relating to the survey were passed to the Furzebrook Research Station, Wareham, where they form part of the Diver Archive. The contents of the archive, and summaries of the unpublished papers are given in Anon (1971).

Diver’s interests at the time were not primarily in molluscs, but the paper and associated notes give a remarkably complete account of the land and freshwater molluscs of the peninsula. 1: 10,560 scale distribution maps were prepared for each species. The paper summarises nine years of accumulated records, including specific surveys of molluscs carried out by Charles Oldham at Diver’s invitation. Oldham was responsible for all identifications.

Diver’s interest in the peninsula was aroused because it had a well documented history of change (Diver, 1933), having increased in size over the previous 300 years by sand accretion, and was subject to extensive heath fires. More changes have occurred subsequently and are well known, as the whole area is now part of the Studland Heath NNR.

There are few published accounts of resurveys to monitor stability and change in land molluscs. Waldén (1992) and Waldén, Gärdenfors and Wäreborn (1991) report on very thorough repeat surveys over much larger areas, where it was possible to use the same precise localities and sampling methods, making quantitative comparisons possible. Diver’s methods and site recording do not allow this exact replication (see below), but the quality and quantity of his data justify a resurvey, on which this study is based. It was carried out in parallel with a resurvey of *Cepaea nemoralis* (L) populations sampled and scored for genetic variation (Cameron, in prep.).

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## THE SOUTH HAVEN PENINSULA

Figure 1 shows the location of the peninsula. Figure 2 shows the peninsula as it was in the 1930s, with key features and localities named. The figure is modified from one made by Diver and reproduced in Anon (1971), itself a simplification of a 1:10560 scale map included in Diver (1933).

Diver (1933) and Wilson (1960) give full accounts of the development of the peninsula. In the seventeenth century, it was a narrow strip of land with the existing west coast, but with its east coast running along what is now the western shore of Little Sea. This area is composed of Bagshot Beds, overlain by blown sand in the north. Subsequently, the peninsula expanded eastward by sand accumulation, more rapidly in the north than in the south. Third Ridge and parts of Southern Heath had developed by the early eighteenth century; Second Ridge and accretions to Southern Heath over the period 1760–1840, and First Ridge in the later nineteenth century. Little Sea and other water bodies were initially tidal and saline. Tidal surges still entered the slacks through the middle of First Ridge in 1900. Between 1880 and 1930 there was some recession of the dunes facing Shell Bay in the north, with blown sand advancing inland. The slacks and lakes were all freshwater by 1930, though the slack between First and Second Ridges retains the name of Saltings Strip.

Nearly all the natural and semi-natural habitats on the peninsula are characterised by very acid and nutrient-deficient soils: podsols and peats on the Bagshot Beds, and similar soils on the sand, which is exceptionally siliceous and calcium deficient. Soil pH even on foredunes drops below 5.5 within 50 years of formation, and to below 5.0 after 100 years (Wilson, 1960).

In the 1930s well-drained areas of both Bagshot Beds and sand were dominated by heathland and *Calluna vulgaris.* Wetlands in Central Marsh, Saltings Strip and Eastern Marsh were mostly open, and often dominated by *Molinia caerulea,* with fringes of *Myrica gale.* Small patches of willow *Salix* spp. and birch *Betula* spp. carr woodland were scattered in these wetlands. They are shown conventionally in Figure 2. Gorse *Ulex europaeus* scrub had developed in places, particularly along the western coast and around Plateau Enclosure. Spread was checked by frequent heath fires, which in the 1930s covered much of the area north of Spur Bog, and further south to the east of Little Sea (Anon, 1971). These fires often encroached well into wetlands.

South of Spur Bog, the land to the west and south of Little Sea held a complex mosaic of habitats, with willow/birch carr, neglected pastures and heaths, open wetlands and some mixed deciduous woodland. Diver doubted if any of the woodland was ancient, but sections of it were, and are, hazel *Corylus avellana* coppice in which primrose *Primula vulgaris* is abundant.

Other habitats of smaller extent were obviously anthropogenic. There were four enclosures (Figure 2), of which Northern and Little Sea were wetland, while Plateau and Pipley were pastures, better drained but abandoned and reverting to scrub. Cottages had existed at the tip of the peninsula, by Plateau Enclosure and at Curlew Cottages; all were merely brick-piles or rubble dumps in the 1930s. The present Ferry Road had been built in 1920, and the roadbed contained Purbeck limestone chippings. Limestone was also used in the construction of Redhorn Quay, long abandoned by 1930.These sites had enhanced calcium levels and significantly richer flora than surrounding heath and swamp.

Carr and Teagle (in Anon, 1971) describe the physiographic and ecological changes which took place up to 1970. These and later changes are shown in Figure 3, which has been modified from Figure 2 using Ordnance Survey Maps, an aerial photograph in Anon (1971), unpublished maps in the Diver Archive and my own observations in the field.

A new dune ridge (Zero Ridge) has developed, extending the coastline by *c.* 100m in the north, dwindling to zero or marginal recession in the extreme south. Most of this growth occurred before 1970. A new wet slack (Zero Slack) has developed between a part of First and Zero Ridges. Erosion of the dunes facing Shell Bay has effectively ceased.

The peninsula was used by the army during the Second World War. A track was built from Plateau Enclosure east to the shore, and this has remained in use to give recreational access to the beach. Its construction seems to have interfered with drainage of the wetlands, which takes place through two cuts open to the sea at either end of Shell Bay. The army also built fortifications in the dunes. These were demolished after the war, leaving piles of concrete rubble causing local calcium enrichment. The largest of these rubble piles had accumulated a calcicole flora by 1970, and was named War Hill (Figure 3, and Anon, 1971). The demolition was accompanied by some severe heath fires, but since then the incidence and extent of fires has been much less than in the 1930s.

Even in the 1930s, there was significant recreational use of the beaches, and the dunes in the extreme south held a row of beach huts. Use intensified after the war. Chalk rubble was used to consolidate areas of dune churned up by vehicles, and eventually the southern area was developed as a formal car park, with fenced off banks and ridges, on which marram dune vegetation has re-established itself. Other parts of the foredunes are also fenced off to protect wildlife and prevent erosion.

The most obvious change since the 1930s, however, is a great increase in tree cover in the wetlands and pastures, and to a lesser extent by encroachment into heath. Most of the wetlands in Central Marsh and Saltings Strip are now covered in dense willow/birch carr woodland, although *M. caerulea* still dominates at ground level, and fringes of *Myrica* are still common. Woodland now covers all of Plateau Enclosure, and most of Pipley Enclosure. A small opening remaining in the latter (Long Glade) is dominated by a dense stand of bracken *Pteridium aquilinum.* Willows and birches surround most of the lake shorelines, and occur in patches along the roadside. Gorse and bracken have also spread in parts of the heathland, but most of this is still dominated by heather *Calluna vulgaris.* Parts of the wetland fringe and wetter heaths are being colonised by *Rhododendron ponticum* despite vigorous efforts to control it.

## SAMPLING IN THE SURVEYS

Most of the molluscan records made by Diver were accumulated while conducting other surveys. Records were attributed to named loci of varying size, and where appropriate to a particular habitat within the locus (Diver and Good, 1934). Short periods were devoted specifically to molluscs, especially in 1932, 1933 and 1934, when Diver was joined for periods by Charles Oldham, who also made records on his own. Records fall into the following categories:

(a) Incidental observations. These records are mostly of large species, but are accumulated over several years, with many visits to most loci in a variety of seasons and weather conditions. Special efforts and repeated visits were made to places where Diver required more specimens of *Cepaea nemoralis* (Cameron, in prep.).

(b) Quadrat and Lattice searches. These were careful ground level searches of one square foot quadrats, mostly on heathland and its fringes, usually carried out in burnt areas to monitor regeneration. Shells recovered were mostly scorched.

(c) Specific visual searches made by Oldham, or Oldham and Diver together at a number of loci. Small species are better represented in these than in (a) above.

(d) Leaf litter samples collected by Oldham. These were searched indoors, and come mainly from woodland in the southern part of the area. Diver (unpublished) does not specify the quantities removed, but judging by the number of specimens recorded they were smaller than those used in 1999.

While most records are qualitative, and do not give a complete inventory of species at a site on any one occasion, their accumulation over many years gives a reasonable picture of distribution. In particular, absences of large and conspicuous species are likely to be genuine.

Only two weeks were available for sampling in 1999, one in July and one in September. The weather was dry throughout in July, and mostly so in September. Most sites were visited at least twice. There are two kinds of record:

(a) From sites of between 200 and 800 $m^2$, which were searched primarily for *Cepaea nemoralis*, but in which all molluscs found were recorded, and some time spent searching for smaller species.

(b) Thorough searches (*c.* 45 minutes) of areas with the same size range, within which *c.* 5 litres of litter were collected, dried, sieved and searched through indoors. Figure 4 shows the locations of the 30 sites sampled in this way.

The methods used in 1999 were more likely to produce complete inventories for individual sites, at least as far as snails are concerned, but the dry weather and limited number of visits to each site probably misses smaller species of slug . As an example, no *Arion intermedius* were found in July, but it was encountered frequently in the damper conditions of September.

Molluscan nomenclature follows Kerney and Cameron (1979).

## RESULTS OF THE SURVEYS

### GENERAL

Diver (unpublished) lists 36 species of land mollusc, of which seven must be regarded as aggregates, and an eighth, *Arion ater*, debatably so (Kerney, 1999). Of the seven, two, *Arion hortensis* agg. and *A. circumscriptus* agg. were recorded as single specimens, and can represent only one species each. *Columella edentula* agg. is almost certainly all *C. aspera*, and is so regarded hereafter, but the aggregates of *Carychium minimum, Cochlicopa lubrica, Vitrea crystallina* and *Euconulus fulvus* are represented by two species each in 1999, and most probably also in Diver's material.

Nine species were found only in single loci. Of these, the record of *Trichia hispida* is dubious as evidence of a living population, being of a single empty shell found in a heavily disturbed dune.

Diver discusses both the faunas of particular habitats, and the habitat and spatial distribution of species. Woodland faunas were the richest, and those from heaths the poorest. These results are discussed further below.

The 1999 survey recorded 43 species, including one aggregate, *Arion circumscriptus*, represented by a single damaged juvenile specimen. *Arion ater* specimens were not dissected; most were black, but some brown specimens were found both in the southern woods and on the roadside. Eight species were recorded from only one site each, but all are represented by living animals, or numerous shells or both. The faunas of the 30 sites with litter samples are shown in the Appendix, in which the sites are grouped by habitat. Woodland sites have, as expected, the richest faunas, and acid wetland the poorest. No attempt was made to sample heathland systematically. Table 1 shows the fauna recorded on each occasion, categorised by range changes (see below).

TABLE 1

Species and aggregates found in the surveys, grouped by observed changes in distribution. An asterisk indicates a distribution possibly affected by sampling differences between surveys (see text). **D1**, found in only one locality in the 1930s; (1), found in only one locality in 1999; **O**, not found in 1999. For occurrence of segregates in 1999, see Appendix.

**Substantial Range Expansions**
*Ena obscura* **D1**
*Punctum pygmaeum**
*Vitrina pellucida* **D1**
*Vitrea crystallina* agg.*
*Aegopinella nitidula*
*Cepaea hortensis* **D1**
*Helix aspersa*

**Static Ranges**
*Cochlicopa lubrica* agg.
*Lauria cylindracea*
*Vallonia excentrica* **D1** (1)
*Nesovitrea hammonis*
*Aegopinella pura*
*Oxychilus alliarius*
*Euconulus fulvus* agg*
*Clausilia bidentata*

**Shifts in Range**
*Vertigo pygmaea* * **D1**
*Vallonia pulchella**
*Arion ater*
*Arion circumscriptus* agg. **D1**, (1)
*Cepaea nemoralis*
*Trichia hispida* **D1**? (1)

**Not recorded in 1930s**
*Arion subfuscus* (1)
*Oxychilus draparnaudi* (1)
*Oxychilus helveticus* (1)
*Boettgerilla pallens* (1)
*Limax maximus*
*Cochlicella acuta*
*Monacha cantiana*
*Trichia striolata*

**Marginal Range Expansion**
*Carychium minimum* agg.*
*Columella aspera* *
*Acanthinula aculeata* *
*Discus rotundatus*
*Limax marginatus*

**Range Reductions**
*Vertigo antivertigo** **O**
*Arion hortensis* agg.* **D1 O**
*Arion intermedius* *
*Oxychilus cellarius*
*Deroceras reticulatum** **O**
*Deroceras laeve** (1)
*Cecilioides acicula** **D1 O**
*Balea perversa* **O**
*Candidula intersecta*
*Cernuella virgata*

## Changes in occurrence and distribution

Five species found by Diver were not found in 1999, and eight (excluding segregates not recognised by Diver) were found in 1999 but not by Diver. Many species found on both occasions show changes in distributions, some of which may be an artefact of differences in sampling technique. Table 1 summarises these changes.

A group of eight species appear to have unchanged distributions, with five more in which the spread is small. *A. pura* and *C. bidentata* remain confined to southern woodlands, and this is almost the case for *C. minimum* agg., *L. marginata* and *A. aculeata* which have each extended to just one site outside, and at no great distance. *V. excentrica* persists only at its single locus, the dry limestone of Redhorn Quay. The remaining species in this group all had wider distributions in the 1930s. *C. aspera* occurs in more locations in 1999, but this reflects the wide spread of litter samples on that occasion.

Amongst apparent range expansions are species not found in the 1930s. Of these, *L. maximus* is now widespread in the southern woods, while *T. striolata, M. cantiana,* and *T.*

*hispida* (dubiously present elsewhere in the 1930s) have colonised the roadside verge, as has one adventitious colony of *C. acuta*, the other being in more typical dune vegetation next to a sailing boat park at the tip of the peninsula. The remaining new arrivals are all single records. Three come from woodland not far from the road, while one is in the National Trust car park.

Other species, present on both occasions, have clearly increased their range. This is particularly clear for *C. hortensis, A. nitidula,* and *H. aspersa* (Figure 5), the last was confined mostly to the immediate vicinity of old cottages in the 1930s. It has spread not only along the road, but into woodland fringes and onto the new Zero Ridge. Of the remainder, *E. obscura* has also spread up the road, but not to the same extent as *C. hortensis.* It was usually found on extraneous sources of lime, such as concrete markers for pipes and cables. *V. pellucida* was known only from the Curlew Cottage ruins in the 1930s, but is now widespread in the woods and in some dunes. Although not usually hard to find, it may be that as with the two small species in this group, sampling in 1999 was more likely to find it.

Two of the largest and most conspicuous species, *C. nemoralis* and *A. ater* (Figure 6) both show overall expansion of range, colonising both the roadside and the new dunes of Zero Ridge, but apparently retreating from the wetland fringes of Central Marsh and Saltings Strip. Two much smaller species, *V. pygmaea* and *V. pulchella,* are no longer found in Pipley Enclosure, but have appeared in the roadside. While easily overlooked, suitable habitats for them have disappeared from the Enclosure.

Of the species not found in 1999, the most striking is *B. perversa.* It was widespread in the southern woods in the 1930s. Special efforts were made to find it in 1999: the trunks of thirty willows and hazels were searched thoroughly in damp, still conditions, in which numerous *D. rotundatus, L. cylindracea* and *C. bidentata* were found crawling. Of the others, the habitat of *V. antivertigo* appears to have disappeared under carr woodland, while the slug absences may be a sampling effect. The failure to find the normally ubiquitous *D. reticulatum* is notable; it was uncommon (3 localities only) in the earlier survey.

Other species survive but have contracted. *C. intersecta* and *C. virgata* were continuously distributed along the roadsides but are now more restricted (Figure 7) . Both have colonised the NT car park in the south. *O. cellarius* has disappeared from all but one woodland site, although it occupies two other anthropogenic ones. Apparent declines in the slugs *A. intermedius* and *D. laeve* are likely to be at least partly artefacts, but that of *D. laeve* (Figure 7) is dramatic, and may reflect a real decline.

## THE EFFECTS OF HABITAT CHANGE

There are a limited number of localities for which reasonably complete data are available from both surveys. In some cases, the habitat had remained similar, while in others it had changed. Table 2 shows details of these localities and the Jaccard index of similarity of the faunas between occasions. The greatest divergence has occurred in the old pastures which have reverted to woodland, and the least within the southern woods together with the dune pasture at the tip of the peninsula. The intermediate sites are, perhaps, more prone to sampling problems: Redhorn Quay, for example, appears unchanged in habitat, but a litter sample was taken in 1999 but not in the 1930s. Nevertheless, the presence of *H. aspersa* in 1999 is a real addition. No species present in the 1930s were missing in 1999.

For other habitats, and especially for wetlands, the same direct comparisons are not available. Declines in diversity seem to be most frequent here, with losses or retreats *(C. nemoralis, A. ater, D. laeve, A intermedius, V. antivertigo)* not compensated for by any new arrivals.

TABLE 2

The number of species/aggregates recorded in each survey, the number common to both, and the Jaccard Index of similarity, for areas sampled on both occasions. Letters indicate the 1999 litter samples used. * indicates the addition of species outside the litter sample, but from the same habitat nearby.

| **SITE** | **1930s** | **1999** | **BOTH** | **INDEX** |
|---|---|---|---|---|
| Pipley Enclosure, D | 15 | 16 | 9 | 0.41 |
| Plateau Enclosure, J and U | 11 | 15 | 8 | 0.44 |
| Central Roadside, L,G and * | 6 | 9 | 5 | 0.50 |
| Curlew Cottages, X | 15 | 16 | 11 | 0.55 |
| Redhorn Quay, Z | 5 | 9 | 5 | 0.56 |
| Northern Roadside, S and * | 9 | 12 | 8 | 0.62 |
| North-west Dune, K | 9 | 8 | 7 | 0.70 |
| 12 and 3 Acre Woods R,T,V,Q,P. | 23 | 20 | 18 | 0.72 |
| Aspen Wood, Pipley Encl. b. | 15 | 16 | 13 | 0.72 |

## DISCUSSION

The South Haven Peninsula is an unfavourable environment for land molluscs, having acid soils and rapidly changing environments. It nevertheless supports about a third of the British fauna in a few square kilometers (Kerney, 1999). No rare species or indicators of ancient woodland are present, and most are species of broad habitat range. There are small duneland and wetland elements, but the latter is very poor compared to what would be encountered in a calcareous district. Over 60–70 years, the fauna has increased slightly: arrivals and expansions exceed eliminations and contractions. Despite significant habitat changes, at least a third of species present show no significant change in distribution, and some changes for others may be an artefact of sampling procedure.

The greatest changes in the fauna of individual locations have been accompanied by big changes in habitat, especially where pasture has succeeded to woodland. On a species-by-species basis, however, it is hard to attribute range expansion to this cause in an unambiguous way. The expansion of *C. hortensis, A. nitidula* and *Vitrea* spp. is concordant with increase in cover, but it is not obvious that habitats as they were in the 1930s were unsuitable for these species. Most species encountered in the woodlands in the earlier survey have broad habitat ranges (Boycott, 1934). A number of shade-loving species have failed to expand their ranges, and the recently formed woodland of Plateau Enclosure, isolated by distance, lacks many species for which it appears suitable.

Equally, the apparently stable woodlands further south have been the site of colonisations and range expansions. The most striking examples are *L. maximus* and *V. pellucida;* the former could scarcely have been missed had it been present in the 1930s. *B. pallens* is certainly a genuine arrival, being unknown in Britain before 1972 (Kerney, 1999). Reductions have also occurred there; while the disappearance of *B. perversa* follows a national decline, especially marked in the east, but certainly noted in Dorset, associated with atmospheric pollution and loss of lichen species (Holyoak, 1978. Kerney, 1999), the sharp decline of *O. cellarius* is inexplicable.

In contrast to the pastures, the development of woodland over the open wetlands has reduced faunas without any sign of colonisation by others. In the pastures and roadsides, there are losses of a few species typical of open habitats, but these are more than compensated for by new arrivals.

The other important natural change in environment is the development of Zero Ridge and Slack. The slack holds only two widespread species, but the ridge has been colonised by *C. nemoralis, H. aspersa, A. ater* and *O. alliarius. C. nemoralis* reached the ridge some time before 1970 (Anon, 1971). For a few decades, this ridge may contain more calcium than did First Ridge in the 1930s (when it was nearly mollusc-free), but *Calluna vulgaris* is already colonising the landward slope in places, and *C. nemoralis* and *H. aspersa* cluster densely round external sources of calcium, such as *Crepidula fornicata* shells dropped by gulls. On Herm, Channel Islands, *C. nemoralis* appeared to colonise dunes once they had been stable for *c.* 30 years (Cameron, Arnold, Dillon and James, 1998). Here they seem likely to die out after 50 or so years of stability: these populations may be very transitory.

Other more local changes have resulted from human activity, which has on balance increased the suitability of sites for molluscs. There were, and are, no rare species to be harmed by disturbance. This beneficial effect was observable along the roadsides and at cottage sites in the 1930s. The road was very new at the time of Diver's work, and the post-1930s expansion of species like *C. nemoralis, A. ater* and *E. obscura* is probably simply the continuation of a process which had already started, and not a consequence of later habitat changes. Other species have clearly moved in by the luck of passive dispersal (e.g. *M. cantiana).* The positive effects of calcium enrichment and environmental management are seen dramatically at the National Trust Car Park, where a rather typical duneland fauna of nine species has established itself on baulks and ridges. In the 1930s, this area yielded one dead shell each for three species. The effect of calcium enrichment is also apparent at War Hill, where nine species live in an area surrounded by acid heath.

These patterns of change, especially of expansions, seem generally to reflect purely local changes. The arrival of *B. pallens,* and the spread of *C. hortensis* and *H. aspersa* are exceptions, reflecting more general trends (Cameron and Killeen, in press). Other species involved appear to have stable populations nationally, or in the case of *C. nemoralis,* to be decreasing, at least in southern England, while clearly expanding locally (Kerney, 1999; Cameron and Killeen, in press). These local trends, set in a non-agricultural area, may be untypical.

There are evident time-lags in colonisation Even the woodlands have acquired species between surveys, including some for which the 1930s environment seems adequate. Perhaps no part of the area is in equilibrium, ie. holding all the species regionally available which could survive had they reached the localities. Rapid habitat changes, and the short time for which the sandy part of the peninsula has existed increase the disequilibrium, while the increase in visitors, often travelling from other coastal localities and parking along most of the roadside increases passive dispersal, and acts as a partial counterbalance.

There appear to be few studies of faunal change in areas of this order of magnitude. In southern Sweden, the pioneering surveys of Lohmander, starting in 1921 (Waldén, 1992), have been used as the basis for resurveys, both to monitor general change (Waldén, 1992), and to investigate the effects of acid rain in particular (Waldén, Gärdenfors and Wäreborn, 1991). These surveys benefit from exact replication of sites and sampling methods, not feasible here, but they cover much larger areas, and do not present details of habitat change at individual sites (other than for measures of soil acidity). Waldén *et al.* (1991) show that marked declines in diversity and abundance had occurred in sites which had low soil pH before the mid-century, and which had been further acidified later. Sites with richer soils were better buffered, and were much less affected. No soil pH values are available here, but that of most sites will be low. There is clearly no general decline; the area is upwind of any major pollution sources (but the disappearance of *B. perversa* should be noted).

Waldén (1992) shows that in the Göteborg region changes in rural sites, most with acid soils as here, were in the direction of increased densities and diversity. Species typical of wooded and shady habitats had generally expanded their site occupancy, and this could be related to an increase in tree and secondary forest cover in the area over the period 1921–1980. The study also reports on a small nature reserve which had a wide range of habitats in 1921, but was completely wooded by 1976: some wetland and open country species had disappeared, and some woodland species had entered. These studies, like this one, give snapshots of changes, but do not yet allow us to pick up different rates of spread or the effects of local barriers or corridors.

Repeat surveys will be a useful way of tracking local changes, especially where a series, rather than a single resurvey can be obtained. They can show changes, particularly amongst well-distributed species, which do not show up in general surveys based on 10 kilometer squares, or even on tetrads (South Haven Peninsula is roughly one tetrad in size). In addition to this paper, following Diver's good example, distribution maps of all species in the 1930s (based on Diver's originals), and in 1999, including those figured here, have been added to the Diver Archive, and deposited with the National Trust.

## ACKNOWLEDGEMENTS

Thanks are due to Professor Bryan Clarke, who drew my attention to the Diver Archive, to Professor Nigel Webb and colleagues at Furzebrook Research Station who made me welcome, helped me find my way round the archive, and provided me with a base, and to Mr. Geoff Hann, National Trust, Studland, for permission to work in the site, and for much helpful information. The study was made possible by the receipt of a Small Ecological Project Grant from the British Ecological Society.

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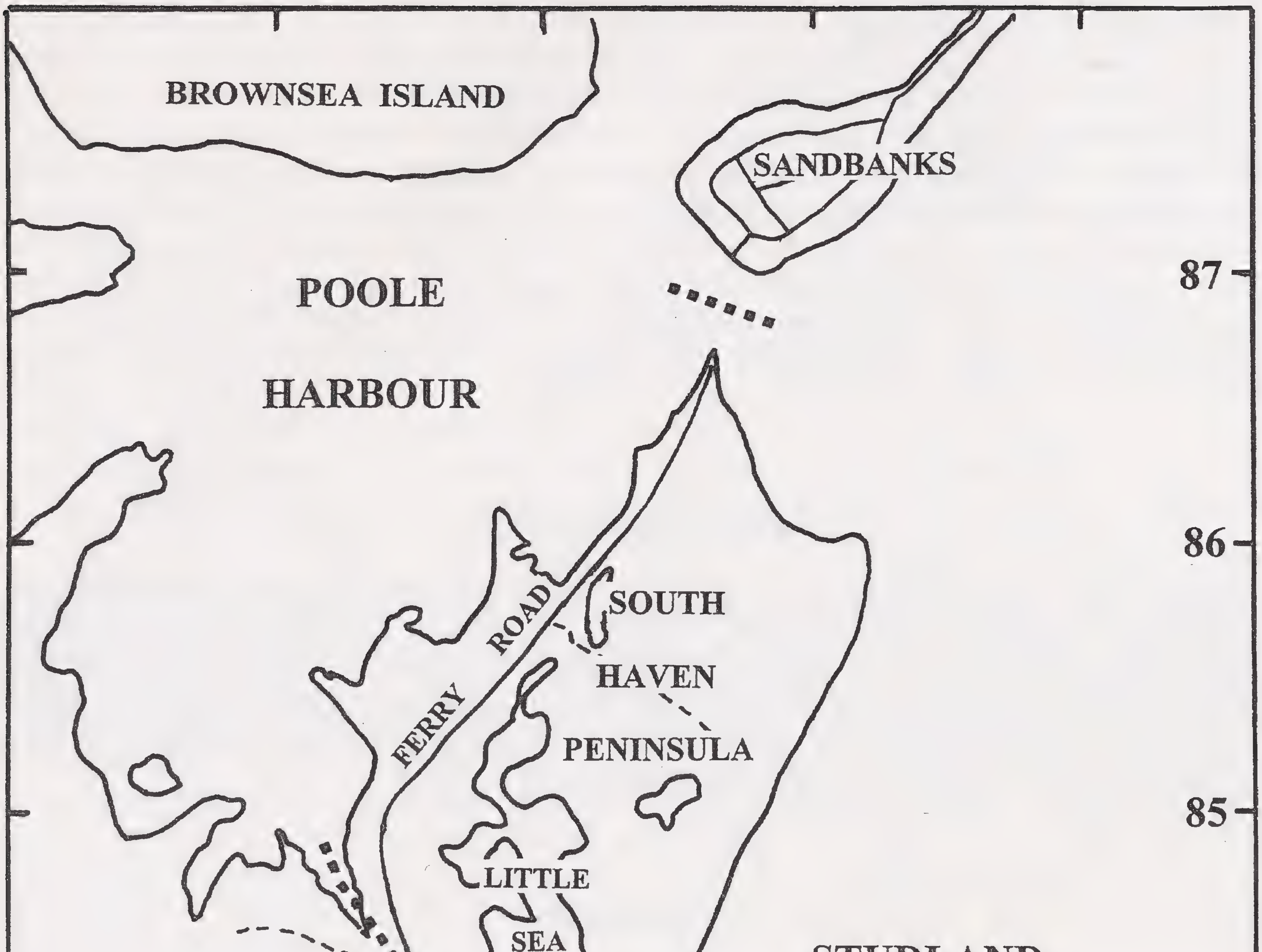


**Figure 1** The South Haven Peninsula and its surroundings. The Ordnance Survey 1 Km grid is shown in the margins. Note that the grid shown in other figures is that provided by Diver (1933), and differs in both scale (1000 yards) and position.

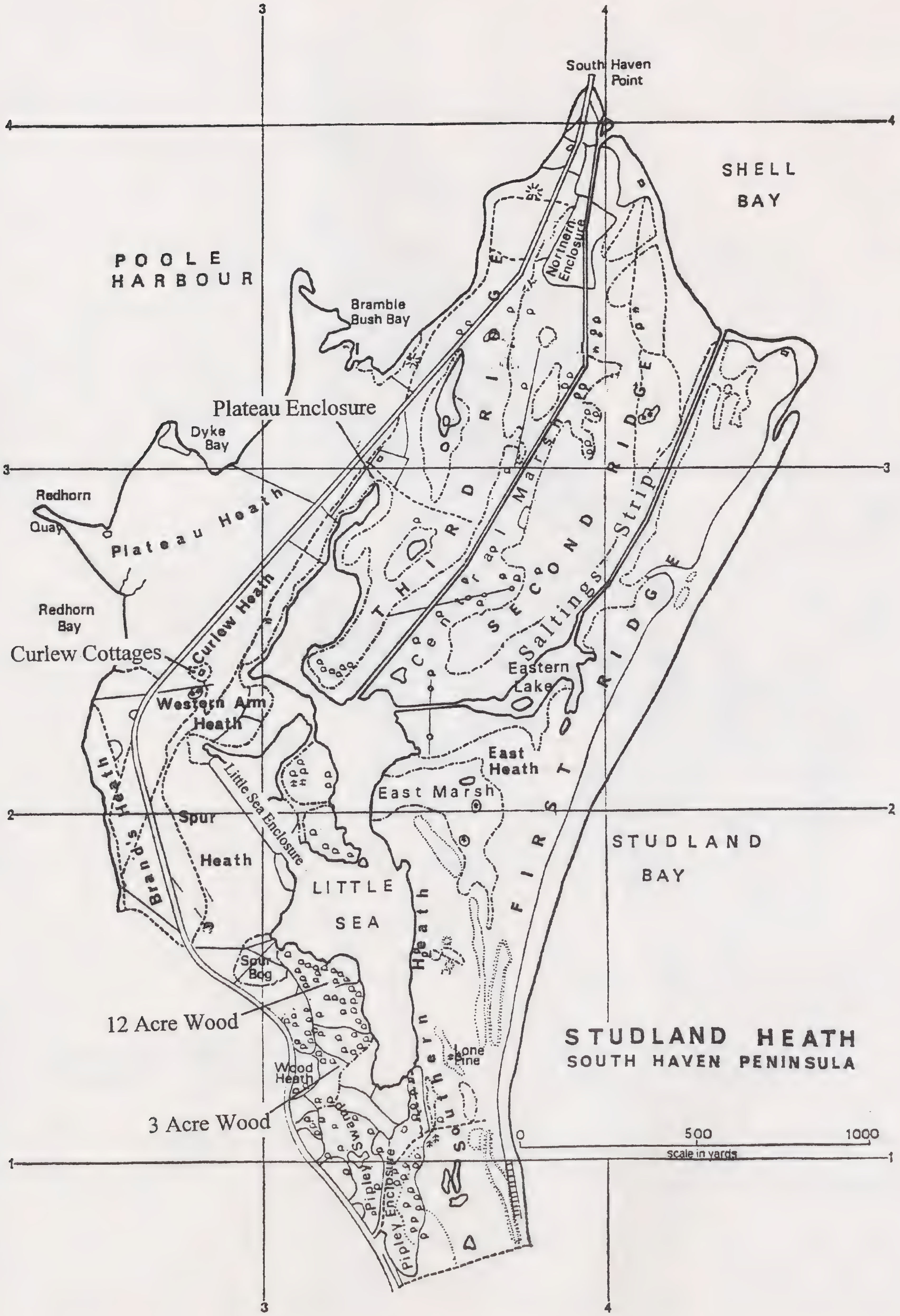


**Figure 2** The study area in the 1930s. Small a..a.. symbols indicate woodland. The grid is Diver's (see under Figure 1).

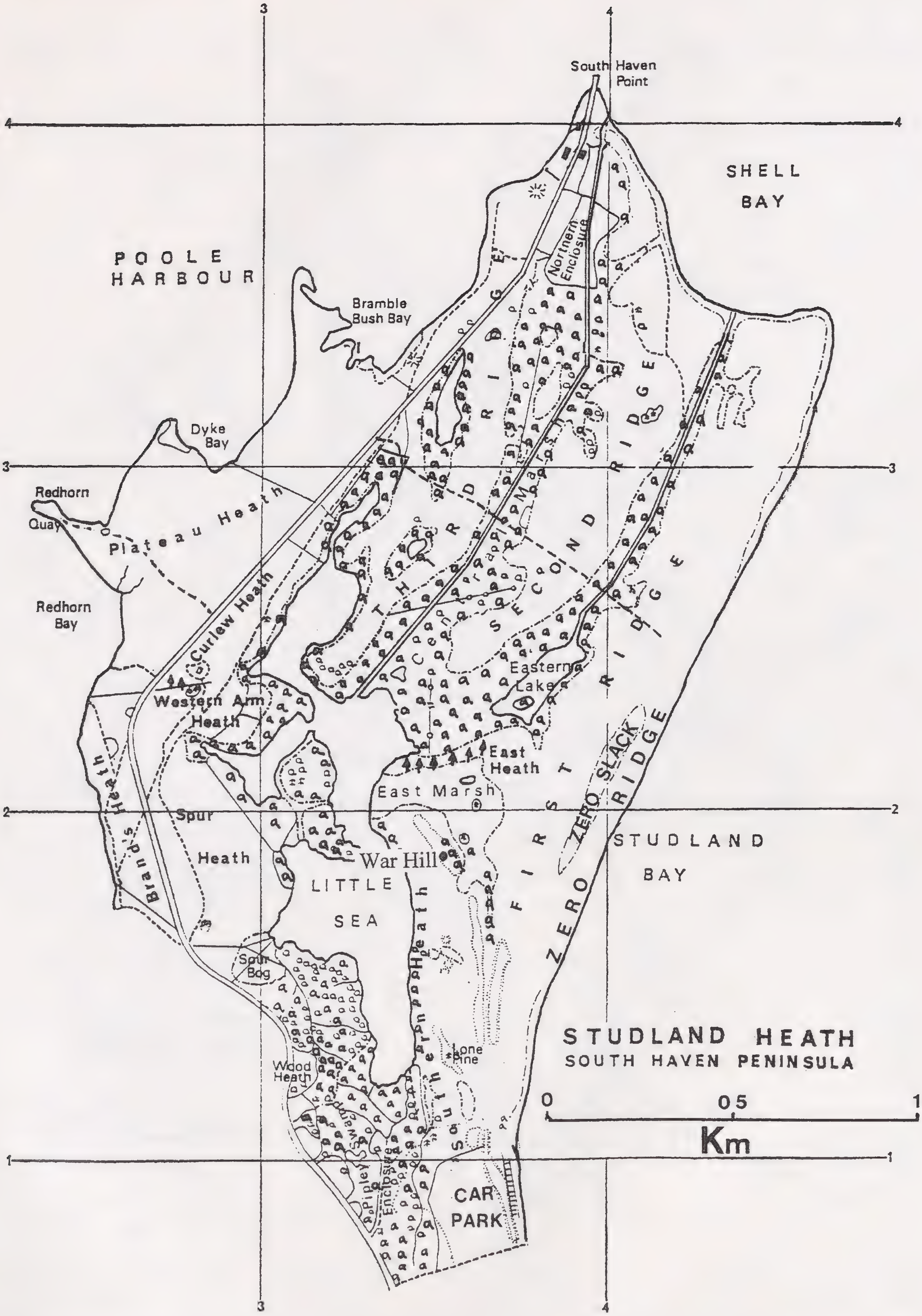


Figure 3 The study area in 1999. Conventions as in Figure 2.

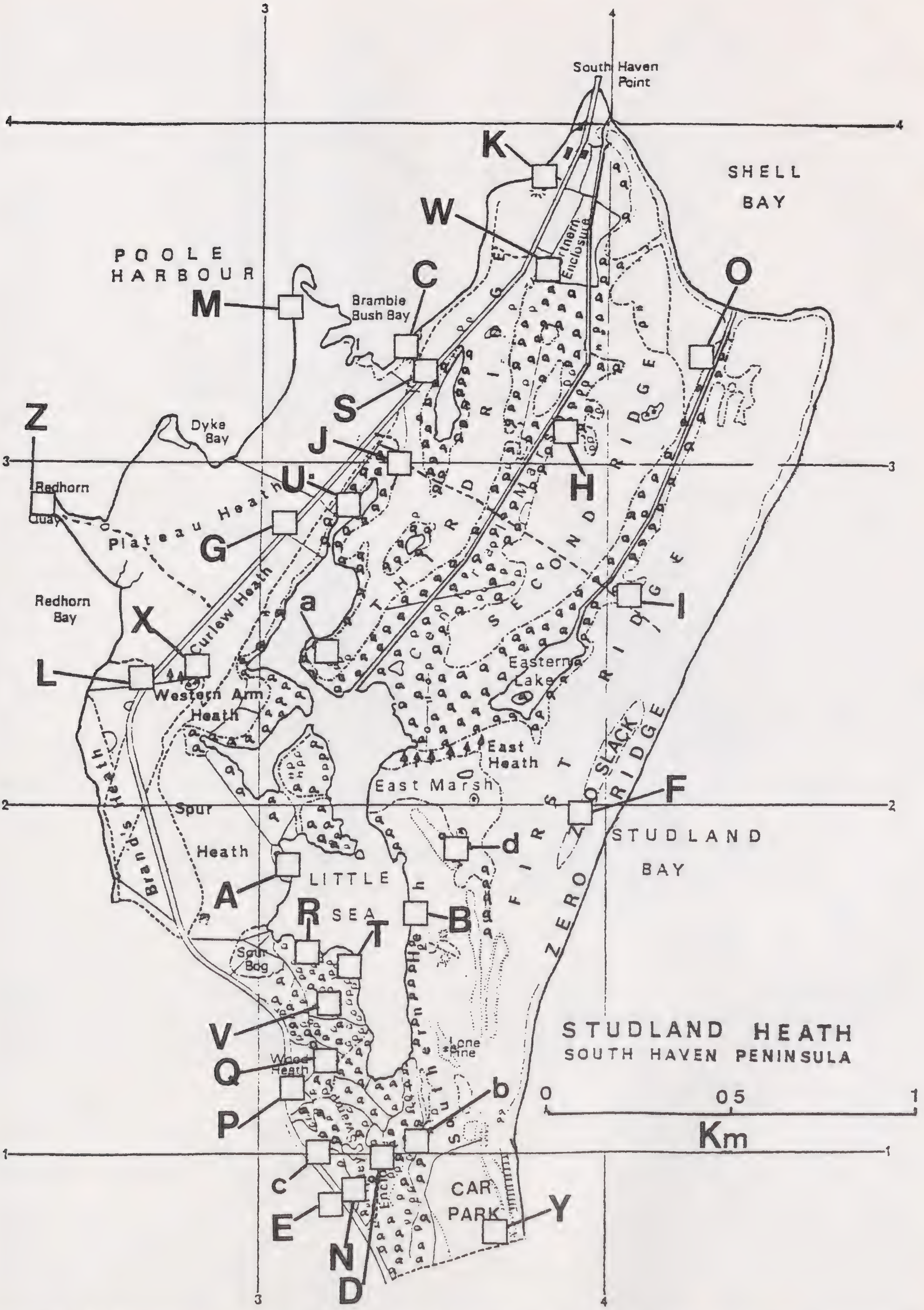
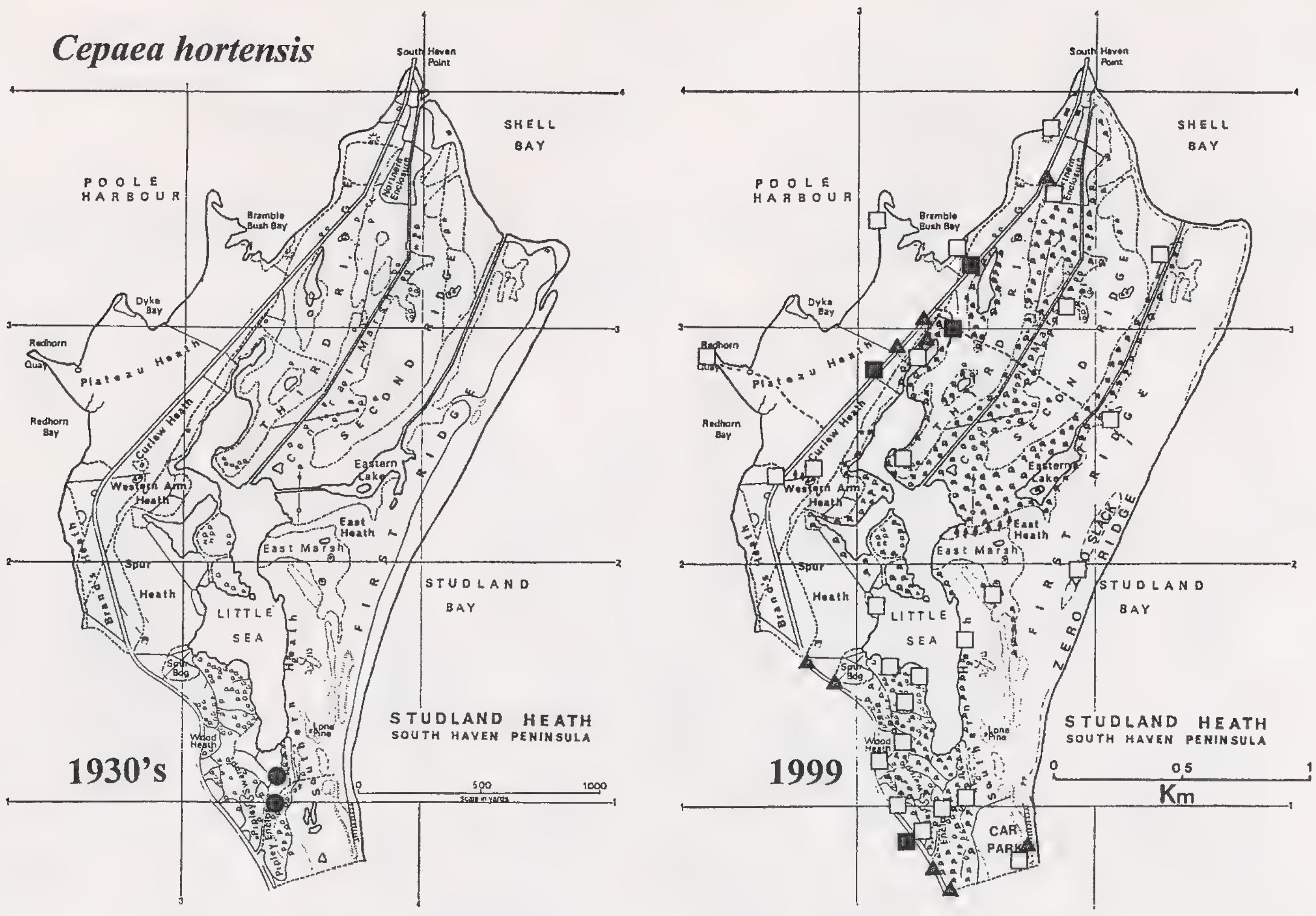
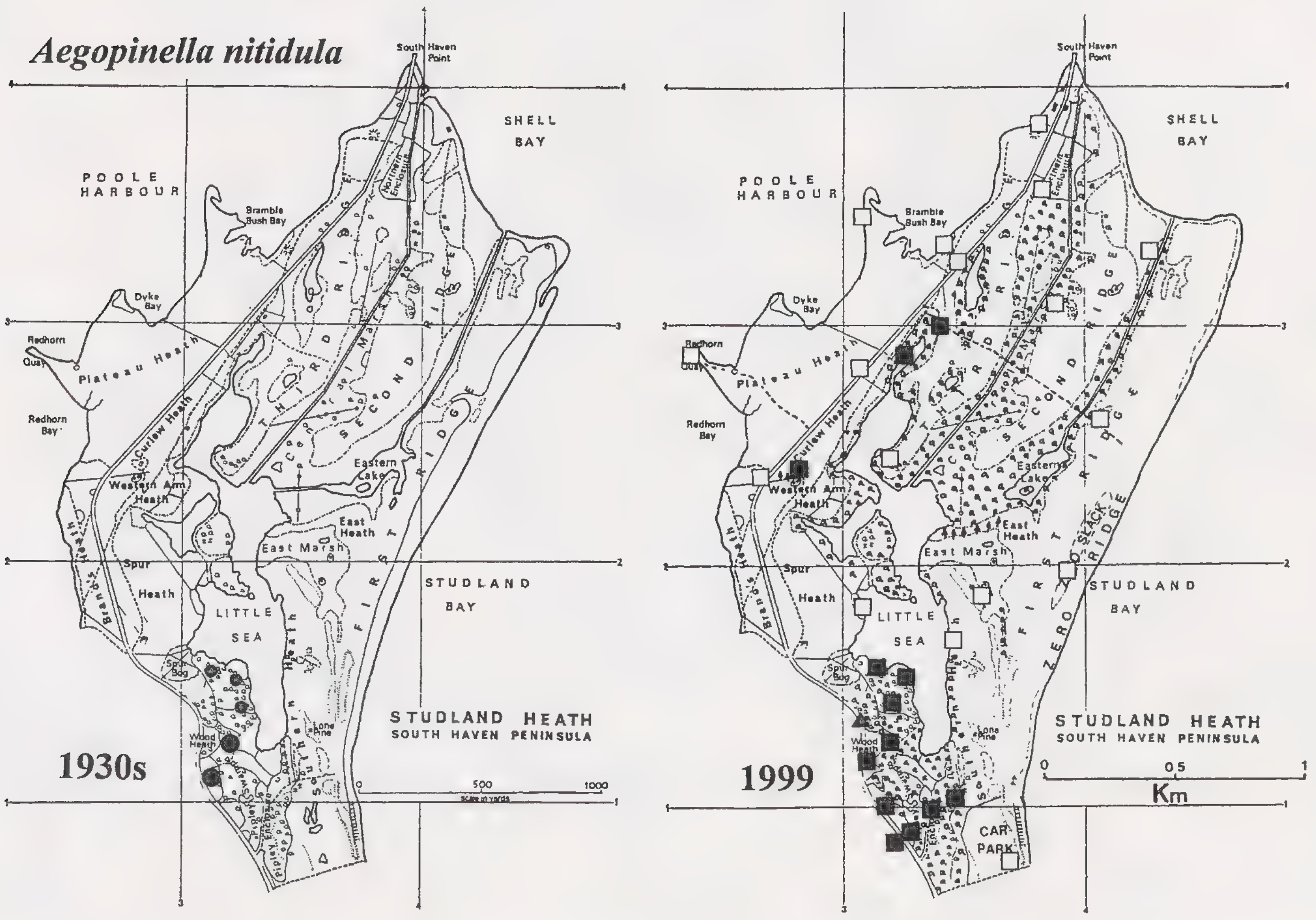


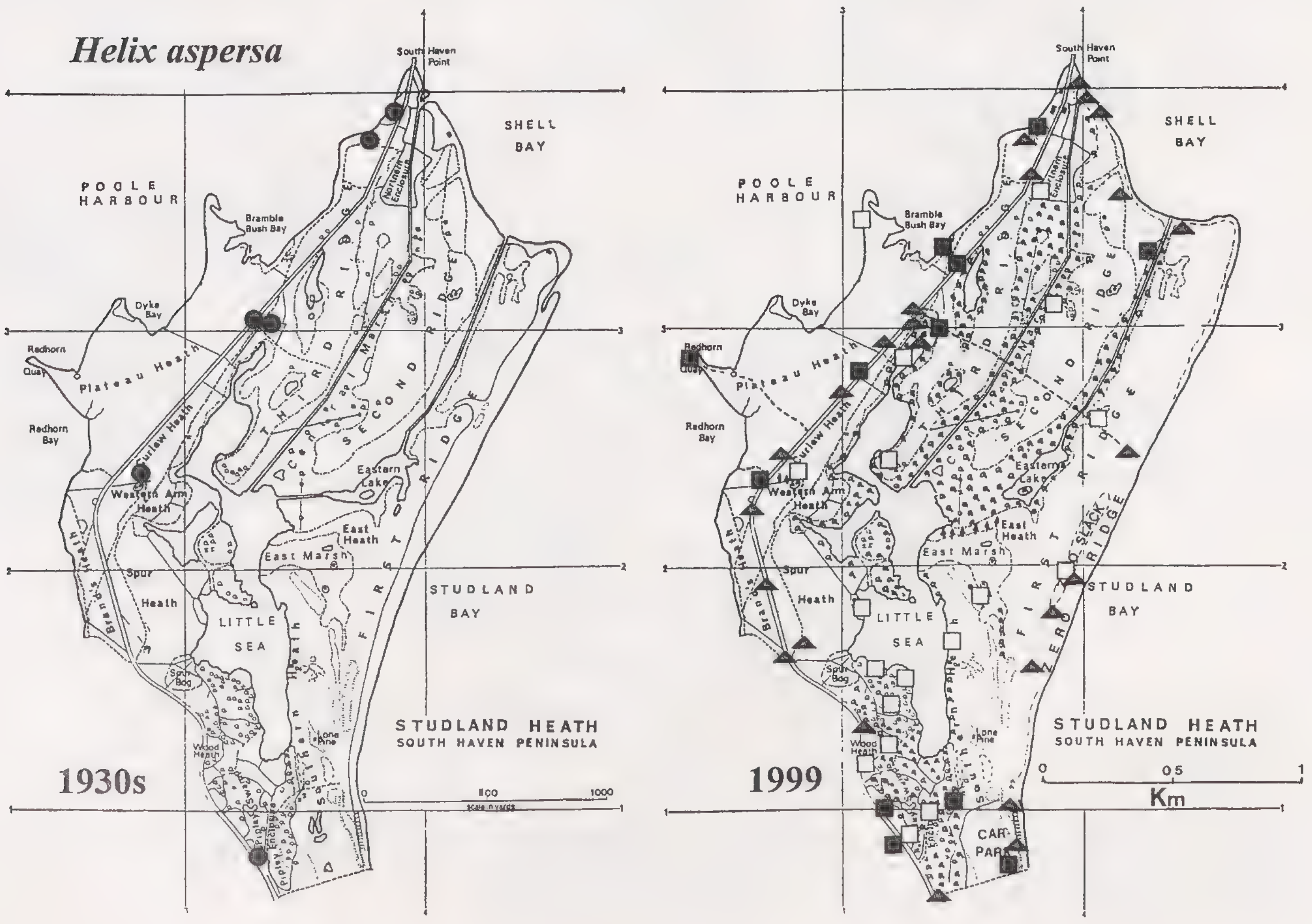
**Figure 4** Locations and reference letters (see Appendix) for 1999 samples where leaf litter was collected. These sites are also shown on subsequent figures.



*Cepaea hortensis*



*Aegopinella nitidula*



*Helix aspersa*

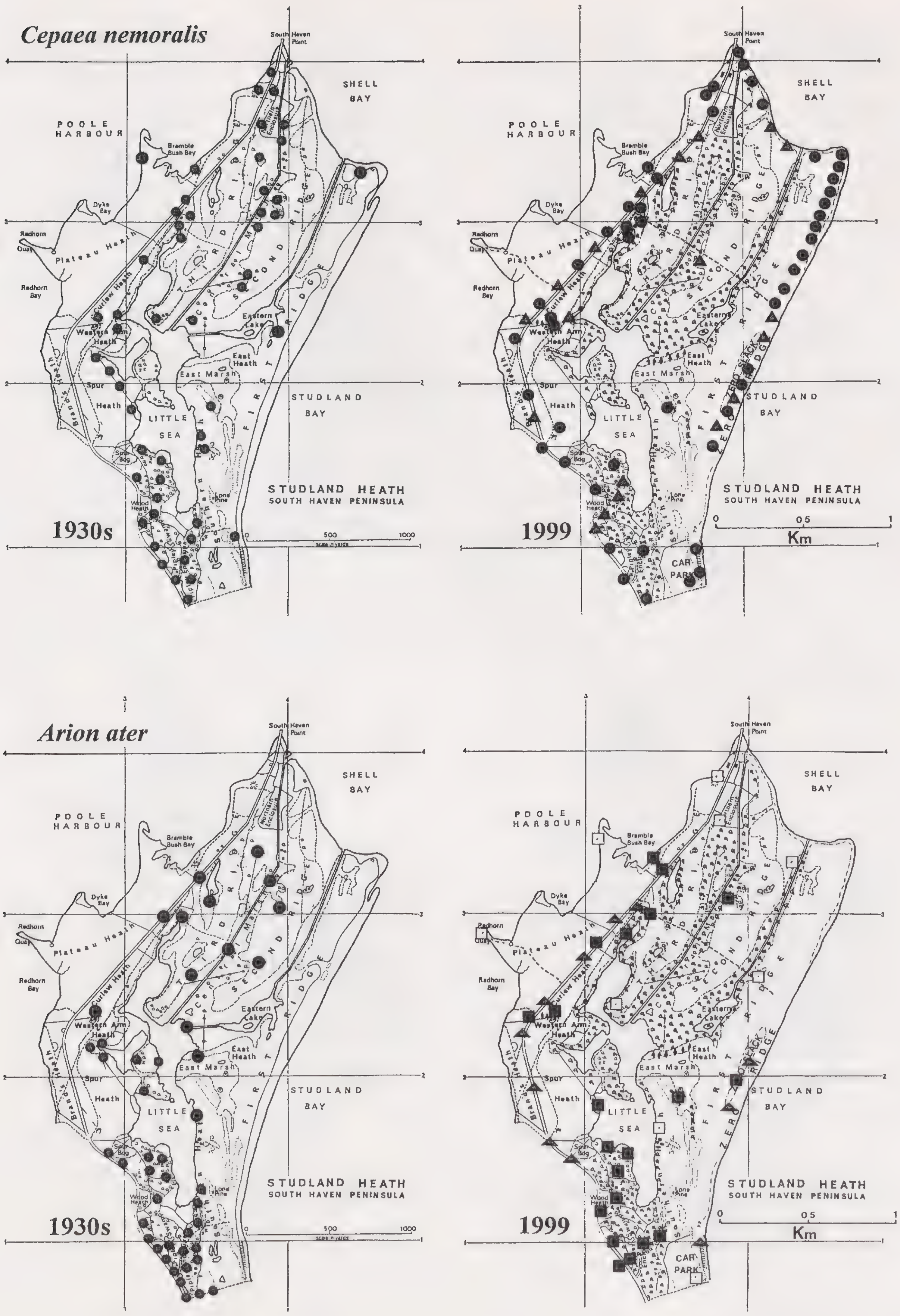
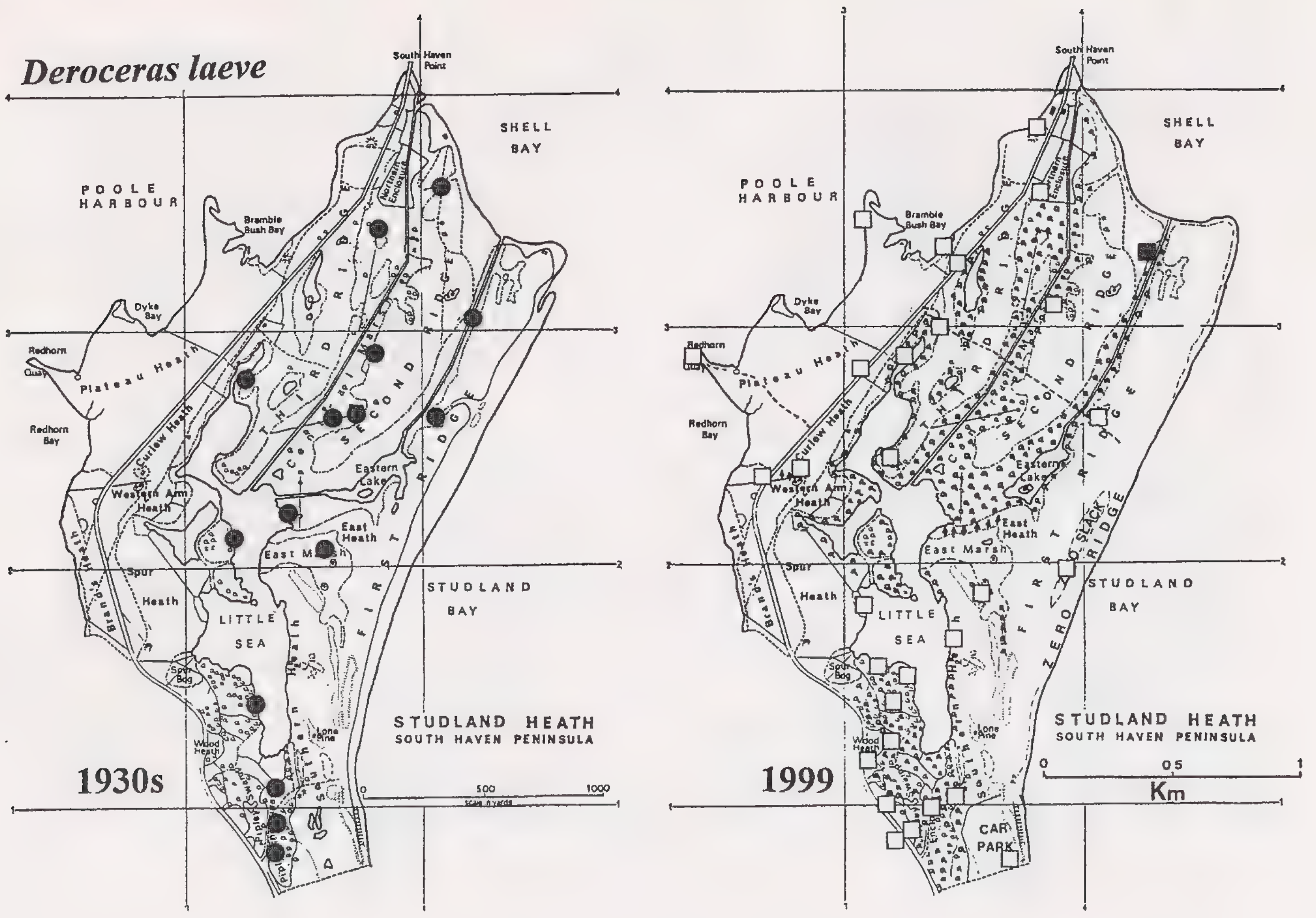
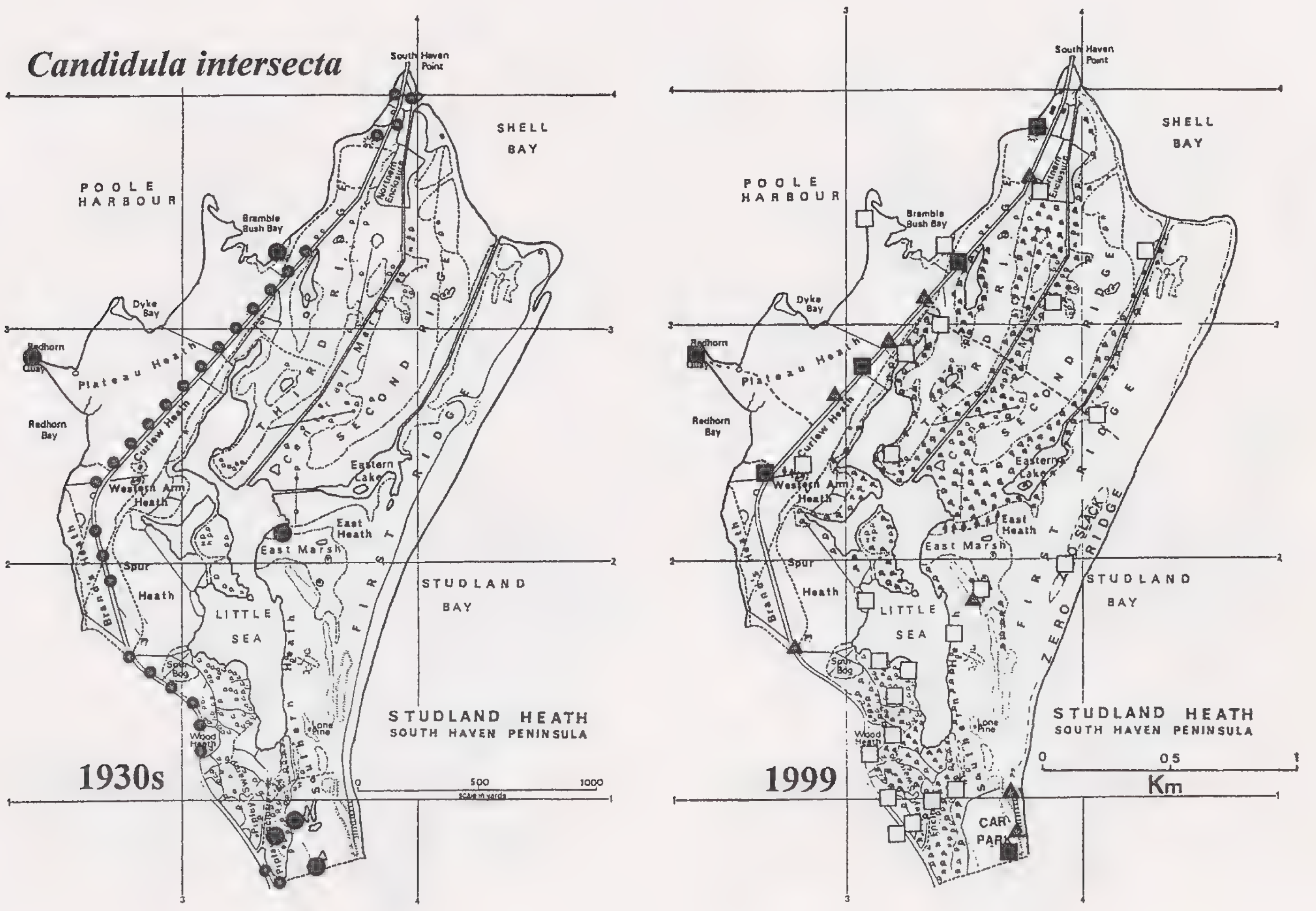


**Figure 6** The distributions of two species showing range shifts within the study area: *Cepaea nemoralis* and *Arion ater*. For *C. nemoralis* in 1999, black circles show sites with populations used for genetic studies (Cameron, in prep.), triangles all other records.

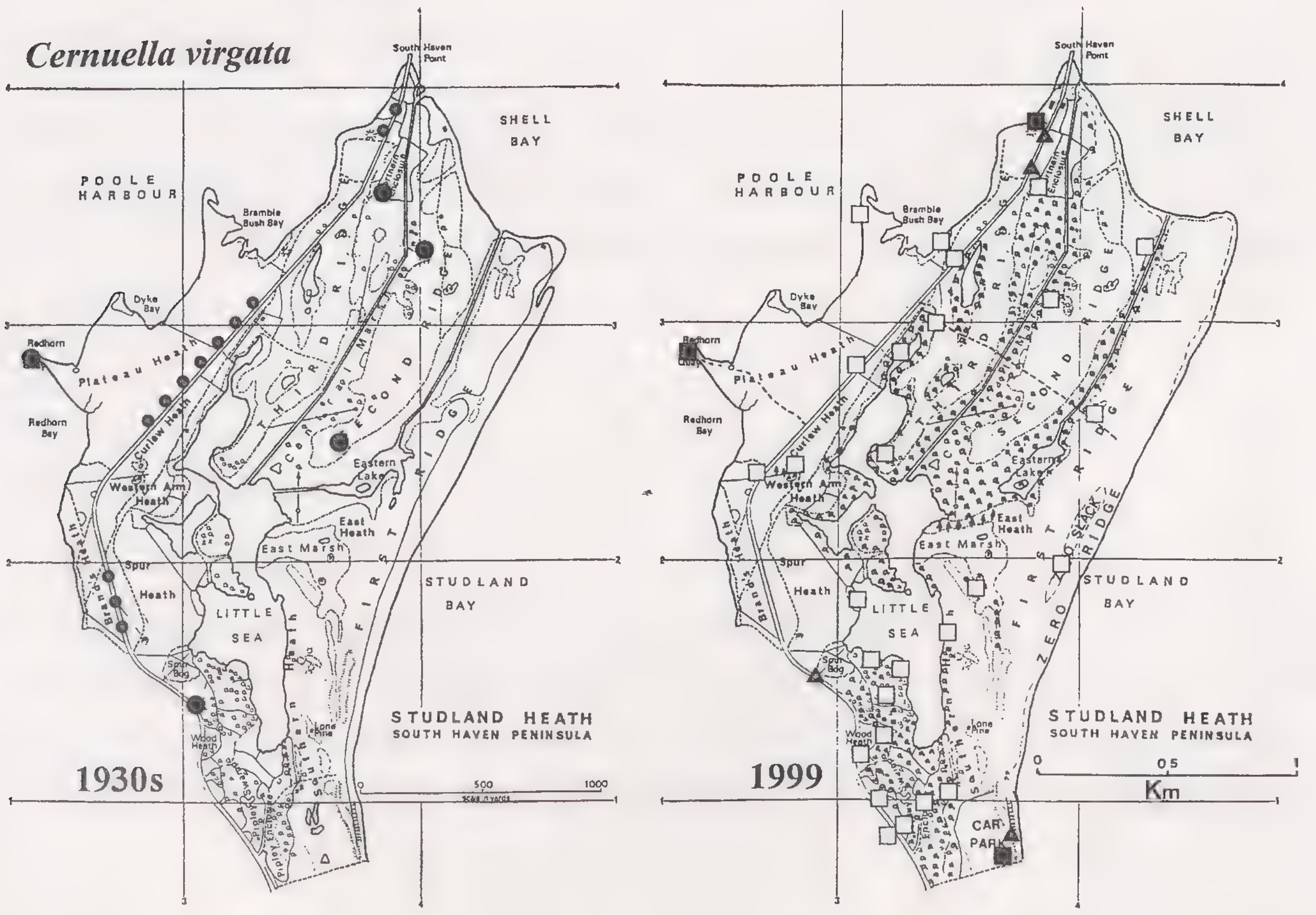
**Figure 5** The distributions of three species with expanding ranges within the study area: *Cepaea hortensis, Aegopinella nitidula* and *Helix aspersa*. In this and subsequent figures small black circles for the 1930's indicate general distribution in their vicinity; larger circles indicate single isolated records. For 1999, black squares indicate occupied litter sample sites, and black triangles all other records.



*Deroceras laeve*



*Candidula intersecta*



*Cernuella virgata*

## APPENDIX

Species recorded in litter/search samples, as shown in Figure 4. From the left, A–F come from wetlands: A and B are lakeshores, H–W are *Molinia*/*Myrica* fringes, O is *Phragmites* and *Molinia*, F is a *Juncus* dominated slack with alders *Alnus glutinosa*. Y and K are dunes with marram grass *Ammophila arenaria* present. Z is Redhorn Quay, short turf with bramble *Rubus fruticosus* agg. C and M are on the Poole Harbour coast, with grasses, gorse and bracken.

J–N are from woodlands. J and U are from Plateau enclosure, with the latter having smaller and more scrubby trees than the former. d is from a Salix wood on War Hill, with lumps of concrete. D and b are in Pipley Enclosure Central, D from around Long Glade (open pasture in the 1930s), b from an aspen wood already present in the 1930s. R,T and V are from 12 Acre Wood, and Q, P, c and N are from 3 Acre Wood and its extension towards the road. c and N are close to the road.

X is the site of Curlew Cottages, a pile of bricks covered with the garden plant Rose of Sharon *Hypericum calycinum*, but surrounded by bracken. E–S are roadside verges. E is on the rubble of an old Toll House, and is effectively a hedgerow; L and G are more open with grassy verges, ditch and gorse; S has a sandy substrate, and is drier.

**Figure 7** The distributions of three species showing range contraction within the study area: *Candidula intersecta*, *Cernuella virgata* and *Deroceras laeve*.
←

| SPECIES | A | B | H | I | a | W | O | F | Y | K | Z | C | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Carychium minimum* | | | | | | | | | | | | | |
| *Carychium tridentatum* | | | | | | | | | | | | | |
| *Cochlicopa lubrica* | | | | | | | | | | | | | |
| *Cochlicopa lubricella* | | | | | | | | | X | X | | | |
| *Columella aspera* | X | X | | | | X | | | | | | X | X |
| *Vertigo pygmaea* | | | | | | | | | | | X | | |
| *Lauria cylindracea* | | | | | | | | | X | X | X | X | X |
| *Vallonia excentrica* | | | | | | | | | | | X | | |
| *Vallonia pulchella* | | | | | | | | | | | | | |
| *Acanthinula aculeata* | | | | | | | | | | | | | |
| *Ena obscura* | | | | | | | | | | | | | |
| *Punctum pygmaeum* | X | X | | | | | | | | | X | X | |
| *Discus rotundatus* | | | | | | | | | | | | X | |
| *Arion ater* | X | | X | | | | | X | | | | X | |
| *Arion circumscriptus* agg | | X | | | | | | | | | | | |
| *Arion intermedius* | | | X | | | X | X | | | | | X | X |
| *Vitrina pellucida* | | | | | | | | | X | | | | |
| *Vitrea crystallina* | | | | | | | | | | | | | |
| *Vitrea contracta* | | | | | | | | | | | | | |
| *Aegopinella pura* | | | | | | | | | | | | | |
| *Aegopinella nitidula* | | | | | | | | | | | | | |
| *Nesovitrea hammonis* | X | X | X | X | X | X | | | | | X | X | |
| *Oxychilus alliarius* | X | X | X | X | X | X | X | X | | X | X | X | X |
| *Oxychilus helveticus* | | | | | | | | | | | | | |
| *Oxychilus cellarius* | | | | | | | | | X | | | | |
| *Oxychilus draparnaudi* | | | | | | | | | X | | | | |
| *Limax maximus* | | | | | | | | | | | | | |
| *Limax marginatus* | | | | | | | | | | | | | |
| *Deroceras laeve* | | | | | | | X | | | | | | |
| *Boettgerilla pallens* | | | | | | | | | | | | | |
| *Euconulus fulvus* | | | | | | | | | | | | | |
| *Euconulus alderi* | X | X | X | | | | X | | | | | | |
| *Clausilia bidentata* | | | | | | | | | | | | | |
| *Candidula intersecta* | | | | | | | | | X | X | X | | |
| *Cernuella virgata* | | | | | | | | | X | X | X | | |
| *Cochlicella acuta* | | | | | | | | | | X | | | |
| *Monacha cantiana* | | | | | | | | | | | | | |
| *Trichia hispida* | | | | | | | | | | | | | |
| *Trichia striolata* | | | | | | | | | | | | | |
| *Cepaea nemoralis* | | | | | | | | | X | X | | X | |
| *Cepaea hortensis* | | | | | | | | | | | | | |
| *Helix aspersa* | | | | | | | X | | X | X | X | X | |
| **TOTAL** | **6** | **6** | **5** | **2** | **2** | **4** | **5** | **2** | **9** | **8** | **9** | **11** | **5** |

| J | U | d | D | b | R | T | V | Q | P | c | N | X | E | L | G | S | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | X |  | X |  |  |  |  |  |  |  |  |  |  |  | 2 |
|  |  |  | X |  |  | X |  |  | X | X | X | X |  |  |  |  | 6 |
| X | X |  | X | X | X | X | X | X |  | X | X | X | X | X | X | X | 15 |
|  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  | 3 |
| X | X |  | X | X |  |  |  | X |  |  |  | X |  |  |  |  | 11 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  | 3 |
| X | X |  |  |  |  |  | X |  |  |  | X | X | X | X |  | X | 13 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  | 2 |
|  |  |  | X | X | X | X | X | X | X | X | X | X |  |  |  |  | 10 |
|  |  |  |  |  |  |  |  |  |  |  | X |  |  |  | X |  | 2 |
| X | X | X | X | X | X | X | X | X | X | X | X | X |  | X |  |  | 18 |
| X |  |  | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 16 |
| X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 21 |
|  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| X |  |  | X |  |  |  |  |  |  | X | X |  |  |  |  |  | 9 |
|  |  | X |  |  |  |  | X | X | X | X | X |  |  |  |  |  | 7 |
|  |  | X | X |  |  | X | X |  |  |  | X | X | X |  |  |  | 7 |
| X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |  | 15 |
|  |  |  | X | X | X | X | X | X | X | X | X |  | X |  |  |  | 10 |
| X | X |  | X | X | X | X | X | X | X | X | X | X | X |  |  |  | 13 |
| X |  |  | X | X | X | X | X | X | X | X | X | X | X |  |  | X | 21 |
| X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 29 |
|  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  | 1 |
|  |  |  |  |  |  |  |  |  |  | X |  | X |  |  |  |  | 3 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
|  |  |  |  | X |  |  |  | X | X | X | X |  |  |  |  |  | 5 |
|  |  | X |  | X | X | X | X | X | X | X | X |  |  |  |  |  | 9 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
|  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  | 1 |
| X | X | X | X |  | X |  |  | X | X | X |  | X |  |  |  |  | 11 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |
|  |  |  | X | X |  | X |  | X | X | X | X |  |  |  |  |  | 7 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X | X | 6 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 3 |
|  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  | 2 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X | 2 |
|  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  | 1 |
|  |  |  |  |  |  |  |  |  |  | X |  |  | X |  |  |  | 2 |
| X |  | X | X | X |  | X |  | X | X | X | X | X | X | X | X | X | 17 |
| X |  |  |  |  |  |  |  |  |  |  |  |  | X |  | X | X | 4 |
| X |  |  |  | X |  |  |  |  |  | X |  |  | X | X | X | X | 12 |
| **15** | **9** | **9** | **18** | **17** | **13** | **15** | **14** | **16** | **17** | **23** | **20** | **16** | **16** | **12** | **13** | **11** |  |

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# ON A NEW SPECIES OF *NESOKALIELLA* AND FURTHER COMMENTS ON THE AFFINITIES OF THE GENUS (GASTROPODA: LIMACOIDEA)

JUSTIN GERLACH[1]

*Abstract* *A third species of the Seychelles endemic limacoid genus* Nesokaliella *is described. The systematic position of the genus is re-examined using a cladistic analysis of the Limacoidea s.l., concluding that* Nesokaliella *belongs to the Gastrodontoidea, but its precise position remains unresolved.*

*Key words* Nesokaliella, *Silhouette, Limacoidea, Gastrodontoidea*

## INTRODUCTION

The Seychelles endemic genus *Nesokaliella* was described in 1998 (Gerlach, 1998) on the basis of material from the islands of Mahé and Silhouette. The available material was sufficient to distinguish two species and to recognise the genus as distinct from *'Kaliella'*, the genus in which the Seychelles forms had been placed previously. However, the affinities of *Nesokaliella* remained obscure due largely to the poor definition of the limacoid (or 'zonitoid') families. It was concluded that the Seychelles genus was probably a euconulid on the basis of an arrangement of cerebral ganglia which appears to be unique to the euconulids within the Limacoidea s.l. (although the restricted number of genera examined was noted). The 1998 revision gave brief consideration to the distribution of the two species, recording *N. minuta* from the north of the island of Mahé and *N. subturritula* from south Mahé and from the islands of Silhouette and Felicite. Adult spirit material was only available from Mahé and the Silhouette population was ascribed to *N. subturritula* on conchological characters alone. The Felicite population is known only from one report (Nevill, 1870), apparently without surviving voucher specimens (Gerlach, 1998). New material from Silhouette led to a reappraisal of the distributions of *Nesokaliella* species, recognising the Silhouette form as a distinct species and allowing a re-examination of the anatomical characters which may facilitate further resolution of the affinities of this genus.

**Abbreviations**

| | |
|---|---|
| BM(NH) | British Museum (Natural History) |
| NPTS | Nature Protection Trust of Seychelles |
| UMZC | University Museum of Zoology, Cambridge |

## SYSTEMATIC DESCRIPTION

### *Nesokaliella intermedia* sp. nov.

**Fig 1**

*Helix (Conulus)*, n. sp.? Nevill 1870: 63 (partim)
*Kaliella subturritula* Martens 1898: 16 (partim)
*Kaliella subturritula* Sykes 1909: 62 (partim)

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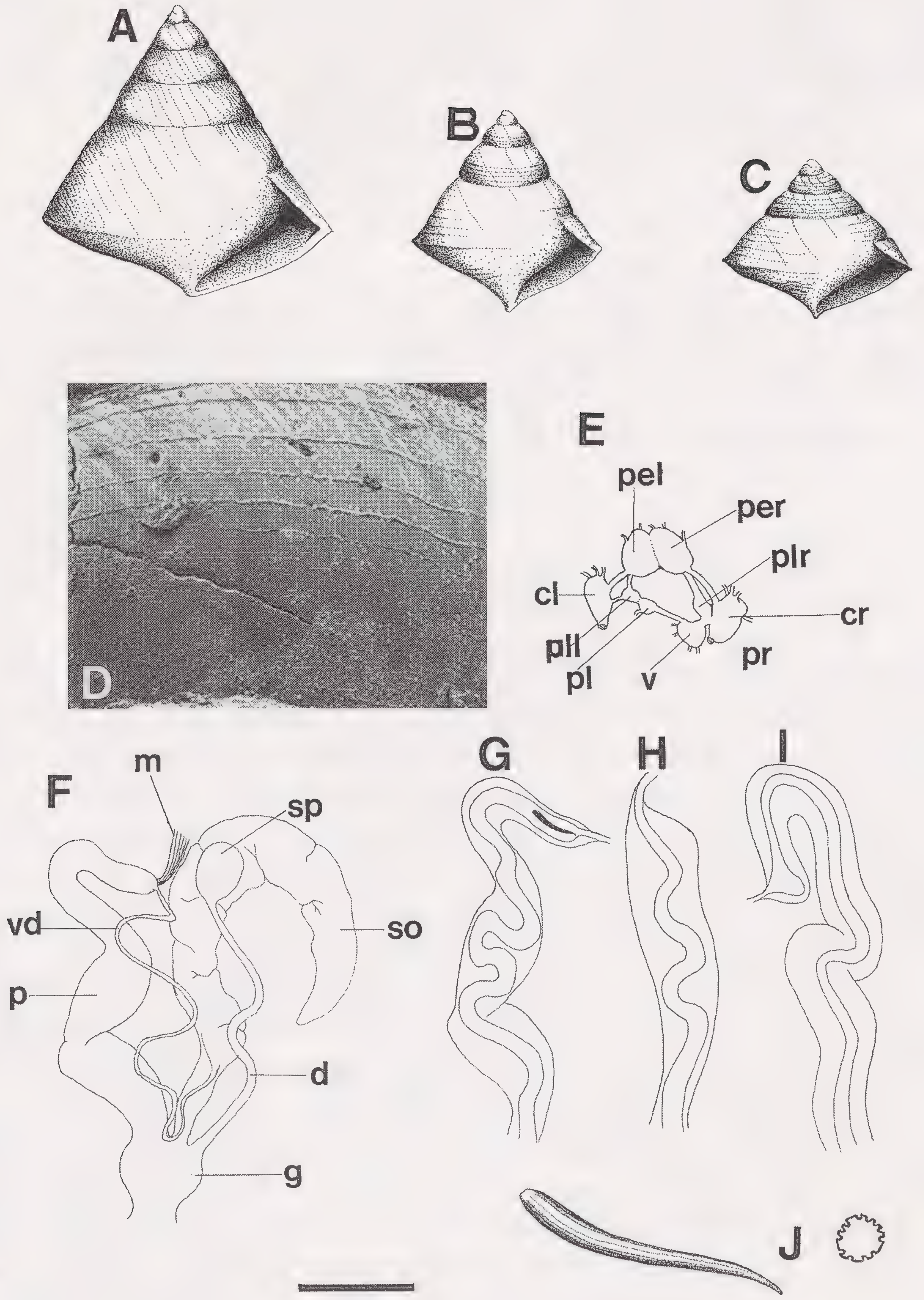

**Fig. 1** *Nesokaliella* shells and anatomy. Scale bar: A–C = 2 mm; D = 0.2 mm; E–I = 1 mm; J = 0.15 mm.

A. *N. subturritula*
B. *N. minuta*
C. *N. intermedia*
D. Shell sculpture of *N. intermedia*
E. Arrangement of cerebral ganglia of *N. intermedia* - cerebral commisures cut.
F. Reproductive anatomy of *N. intermedia*
G. Penis of *N. intermedia,* showing location of spermatophore
H. Penis of *N. subturritula*
I. Penis of *N. minuta*
J. Spermatophore from *N. intermedia,* side view and cross section

Key **cl** left cerebral ganglion; **cr** right cerebral ganglion; **d** spermatheca duct; **g** genital atrium; **m** penial retractor muscle; **p** penis; **pel** left pedal ganglion; **per** right pedal ganglion; **pl** left parietal ganglion; **pll** left pleural ganglion; **plr** right pleural ganglion; **pr** right parietal ganglion; **so** spermoviduct; **sp** spermatheca; **v** visceral ganglion; **vd** vas deferens.

*Kaliella subturritula* Germain 1921: 433 (partim)
*Kaliella subturritula* Germain 1934: 122 (partim)
*Kaliella subturritula* Lionnet 1984: 241 (partim)
*Kaliella subturritula* Gerlach 1987: 17 (partim)
*Nesokaliella subturritula* Gerlach 1998: 18 (partim)

*Holotype* NPTS M1999.1 (Jardin Marron, Silhouette 18/1/99, collected by J. Gerlach).

*Paratypes* NPTS M1999.2 (Jardin Marron, Silhouette 18/1/99, collected by J. Gerlach); NPTS M1998.5, Gratte Fesse, Silhouette, 3/8/98, collected by J. Gerlach), UMZC I.22,528 (Jardin Marron, Silhouette 18/1/99, collected by J. Gerlach).

*Other material* Silhouette: 1 adult (BM(NH) un-numbered (ex Sykes colln. 1908), 11 juveniles (NPTS M1997.3, Jardin Marron 2/7/90–2/8/90; NPTS M1999.3; Jardin Marron 18/1/99).

*Measurements (mm)*

| | **Height** | **Diameter** | **Whorls** | **N** |
|---|---|---|---|---|
| **Holotype** | 2.8 | 3.2 | 6 | |
| **Range** | 2.0–2.8 | 2.2–3.2 | 6 | 4 |
| **Mean ± sd** | 2.35±0.41 | 2.65±0.44 | 6±0 | |

*Description* Shell (Fig. 1C & D) conical with 6 almost straight sided whorls, protoconch of 2 smooth whorls. Whorls ornamented with fine regular radial growth lines (50 $mm^{-1}$), and 10 fine spiral striae (44 $mm^{-1}$ on body whorl), only the basal 7 striae are distinct. Sculpture continues onto the underside. Keel sharply angled. A sutural ridge is present on all whorls. Umbilicus open but very small (5% of shell diameter). Shell very thin, slightly glossy, translucent, with a thin, horn coloured periostracum. Mouth edge simple.

Body. Tail slightly flattened, no caudal horn. Sole tripartite. Light brown, tentacles darker. Mantle brown, without darker mottling. Mantle border brown.

Radula formula = 54+9+1+9+54.

Reproductive anatomy (Fig 1F.). Genital atrium slightly inflated. Spermoviduct elongate, simple in shape. Spermatheca duct long and narrow, arising from base of spermoviduct. Spermatheca oval, 0.8 mm longest dimension. Penis elongate (3 mm), very narrow (0.1 mm). Penis enclosed by tunica. No epiphallus detectable externally or indicated by internal structure. No penial diverticulae or ornament. Penial retractor muscle terminal. A small, elongate structure was present in tip of penis, this was initally interpreted as a spicule but its position and ornament suggest that it is the distal portion of a spermatophore. This structure is elongate (0.4x0.05 mm), slightly curved; grey with fine longitudinal striae.

*Derivation of name* *intermedia*, Latin for **intermediate,** referring to its apparent similarity to both *N. subturritula* and *N. minuta.*

*Distribution* Silhouette (Jardin Marron, Mon Plaisir, *Pisonia sechellarum* forest, Gratte Fesse). Arboreal species, rarely found in leaf litter on the ground.

*Comparisons* *N. intermedia* resembles *N. minuta* superficially in its small size and uniform brown colouration. Adult shells were initially mistaken for juvenile *N. subturritula* due to the presence of radial microstriae which are found in *N. subturritula* but not

*N. minuta.* Penial shapes do not differ greatly, re-examination of dissections shows that the apparent differences figured in Gerlach (1998) are due to the accidental removal of the penial tunica in the specimen of *N. minuta* and the obscuring of the true penis shape by the retained tunica in *N. subturritula*, corrected figures are given in Fig. 1. Differences between the taxa are summarised below:

| | ***N. subturritula*** | ***N. minuta*** | ***N. intermedia*** |
|---|---|---|---|
| **Spiral striae** | 0 | 5 | 10 |
| **Radial striae** | present | absent | present |
| **Height/diameter** | 0.94–1.04 | 1.14–1.3 | 0.88–0.91 |
| **Mantle colour** | grey+black | mottled brown | uniform brown |
| **Radula marginals** | 27 | 39 | 54 |
| **Genital atrium** | normal | normal | inflated |
| **Penis shape** | elongate | terminally inflated | elongate |

## DISTRIBUTION PATTERNS AND THE FELICITE RECORD

The presence of three distinct species on two islands suggests that isolated populations readily diverged to species level. This suggests that the Felicite form should be described as a new taxon, however, this is prevented by the lack of specimens. Felicite is a small, relatively low (250 m) island in contrast to Mahé and Silhouette which reach 996 m and 774 m respectively. On these islands *Nesokaliella* is restricted to high altitude forests above 250 m. The islands of Praslin and La Digue are near Felicite and superficially appear to offer more suitable high-forest habitats, however, no members of the genus have ever been recorded from these islands, raising questions as to the accuracy of the Felicite record.

The Felicite record rests on a single report of *'Helix (Conulus)*, n. sp.?' (Nevill 1870). This was not described at the time and the Felicite record was omitted from the subsequent description of *'Helix sub-turritula'* (Nevill & Nevill, 1871). Furthermore, no Felicite specimens were listed by Nevill (1878), suggesting that the 1870 record was an error; either a misidentification or a labelling mistake, subsequently corrected but not elaborated on by Nevill. No *Nesokaliella* were collected on Felicite by subsequent visitors to the island (Sykes, 1909; Lionnet, pers. comm.).

If Felicite is removed from the distribution of *Nesokaliella* the genus is restricted to the high forests of Mahé and Silhouette and belongs to the relict high-altitude and mist forest fauna of these islands.

## AFFINITIES

The affinities of *Nesokaliella* are difficult to determine, largely because of the lack of clear diagnostic characters for the limacoid families. As discussed in Gerlach (1998) the genus appears to be euconulid. A more detailed dissection of the Silhouette material has provided some new information which may clarify the situation.

The previous discussion of *Nesokaliella* demonstrated that the genus showed closest affinity to the Euconulidae, Urocyclidae and Limacoidea (Zonitoidea in Gerlach, 1998). The most distinctive feature of the new material is the presence of a portion of the spermatophore. The longitudinal striae on the spermatophore are unusual but are recorded in the Chronidae (e.g. *Orpiella macgillivrayi;* Baker, 1941). The presence of a penial tunica in *Nesokaliella* is recorded in several limacoid families but has often been overlooked (Hausdorf, 1998). The insertion of the spermatheca duct at the junction of the spermoviduct and penis is a common euconulid character and is found in *Nesokaliella*. Spermatheca duct insertion has been suggested as defining the family (Baker, 1941) although exceptions to the pattern are known (e.g. Verdcourt, 1992) and the character is also found in the gastrodontids (Pilsbry, 1946). As noted previously (Gerlach, 1998), the

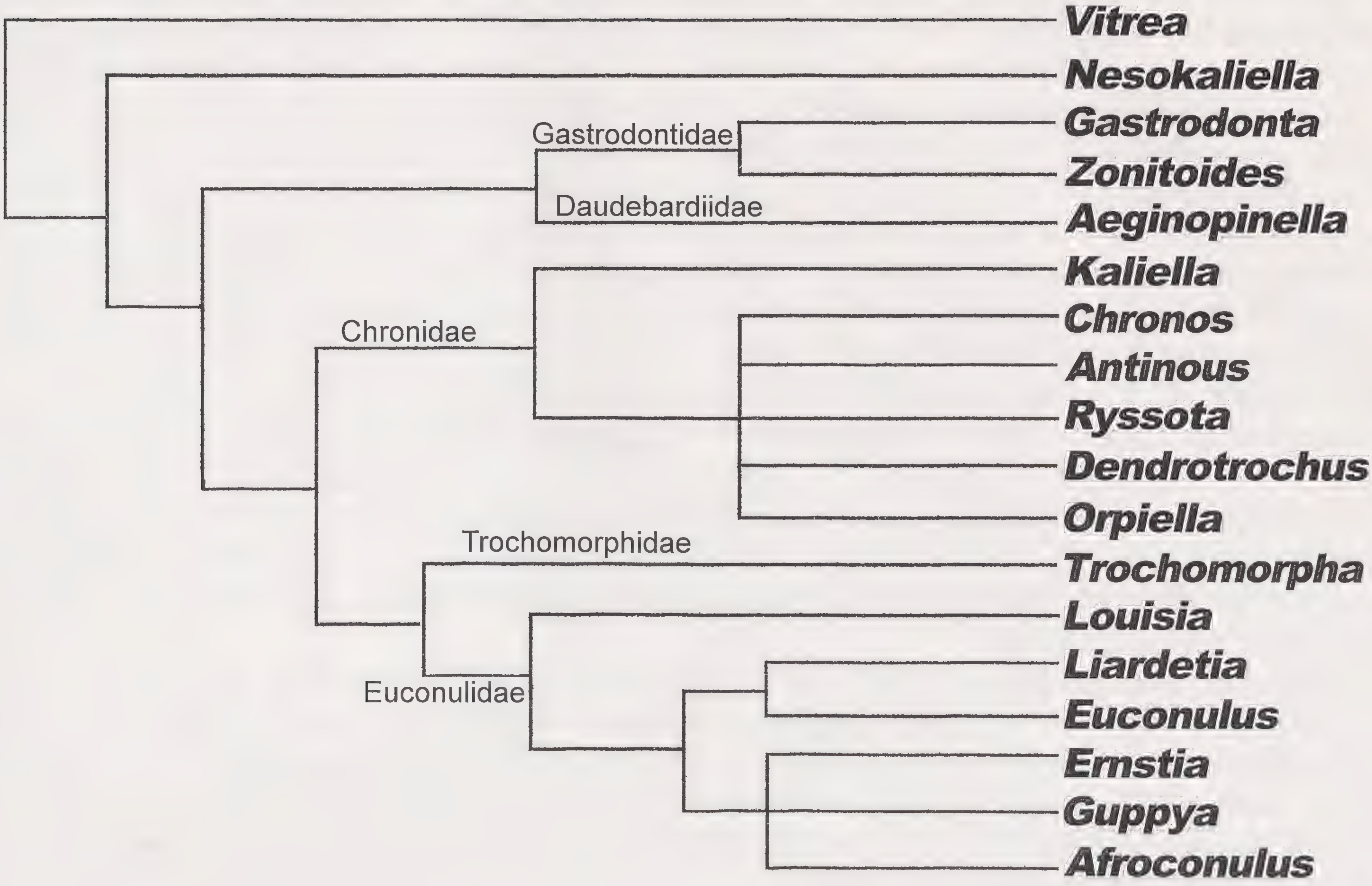

**Fig. 2** Gastrodontoid phylogeny.

arrangement of cerebral ganglia in *Nesokaliella* is the only anatomical character clearly separating the limacoid families at present, although this rests on dissections of very few taxa. Available data suggest that the *Nesokaliella* pattern of short connective commissures and approximately equidistant pleural, pedal and cerebral ganglia and the visceral ganglion contacting the right parietal ganglion are found only in the euconulids. Of these apparently euconulid characters the close proximity of the left parietal ganglion to the left pleural relative to the visceral is also found in the gastrodontids, as is the proximity of the right pleural and cerebral ganglia (although there is some variation in gastrodontids). The former character has been interpreted as being plesiomorphic (Tillier, 1989) and may not be useful in determining affinities. The latter is apparently restricted to some gastrodontids, euconulids, trochomorphids and urocyclids.

The only recent attempt to examine the relationships between the limacoid families (Hausdorf, 1998) provides clear definitions of most groups although some of the families used may be paraphyletic (e.g. Helicarionidae and Euconulidae). Under Hausdorf's (1998) definitions *Nesokaliella* belongs to the Dyakioidea + Gastrodontoidea based on the presence of a caudal pit and the absence of penial papillae (characters present in other Limacoidea; Hausdorf, 1998). The genus can be further restricted to the Gastrodontoidea by the lack of a stimulator and papillae. The presence of minor venation in the lung is also a character of this group but is not known in *Nesokaliella*. Within the Gastrodontoidea *Nesokaliella* appears to be closest to the Chronidae, sharing the thick walled spermatophore with *Orpiella* and the absence of a flagellum with *Ryssota* although certain characters such as the position of the spermatheca duct on the genital atrium and the inflation of the atrium could be interpreted as resembling the Microcystinae states (duct on the penis rather than the vagina and inflated 'uterus'; Hausdorf, 1998), although the long spermatheca duct would exclude it from the Microcystinae and other Euconulidae.

A cladistic analysis of the Gastrodontoidea was carried out (Fig. 2) using published anatomical descriptions of a range of genera within the main families (Godwin-Austen, 1908; Baker, 1941; Pilsbry, 1946; Van Mol & Bruggen, 1971; Verdcourt, 1992; Riedel, 1980). The characters used are given in Table 1 and the full list of taxa and character states in Table 2. The characters were analysed with *Hennig86* (Farris, 1988), using a branch-and-bound algorithm and *Vitrea* (Pristilomatidae = Vitreidae) as the outgroup. The analysis produced a single tree of 31 steps (confidence index 0.61 and retention index 0.82) which failed to locate *Nesokaliella* in any of the existing families. Of the characters used, the presence of an epiphallus may be difficult to determine and it has been suggested that the region of the *Nesokaliella* penis containing the spermatopohore could be considered to be an epiphallus (Hausdorf pers. comm.). Additionally the outgroup used is the only pristilomatid lacking an epiphallus (Riedel, 1980). If the outgroup is assumed to have an epiphallus 16 equally parsimonious trees of 32 steps would be produced (confidence index 0.59, retention index 0.81). A strict consensus tree identifies four groupings; *Nesokaliella*, the Chronidae, Gastrodontidae + Daudebardiidae and Euconulidae + Trochomorphidae. The relationships between these groups is unresolved. Interpreting the distal portion of the *Nesokaliella* penis as an epiphallus does not alter these groupings or the tree statistics.

Based on the available data it is probable that *Nesokaliella* belongs to the Gastrodontoidea, but its precise position within this group remains uncertain. As the anatomy of many of the constituent genera are very poorly known and the relationships of the main gastrodontoid groups remain unresolved (Hausdorf, 1998) it may not be surprising that *Nesokaliella* remains difficult to place in existing taxonomic schemes. As the Seychelles islands retain an ancient, isolated fauna, it is possible that the anatomy of *Nesokaliella* reflects the plesiomorphic conditions in the Gastrodontoidea.

TABLE 1
Characters used in cladistic analysis

1. Caudal horn present
2. Mantle lobes present
3. Penis elongate (length >3xwidth)
4. Penial tunica present
5. Penial papillae present
6. Caecum on penis
7. Epiphallus present
8. Flagellum on epiphallus
9. Chalk sac present on epiphallus
10. Spermatheca duct shorter than penis
11. Spermatheca reduced (width <4xspermatheca duct width)
12. Spermatheca originating on penis
13. Genital atrium round
14. Connection between penis and spermoviduct
15. Stimulator dart present
16. Dart sac present
17. Thin walled spermatophore
18. Minor venation present on lung
19. Right ommatophoral retractor muscle passing between penis and spermoviduct

TABLE 2

Character states of taxa used in cladistic analysis

| | |
|---|---|
| *Vitrea* | 00111 00001 100000 001 |
| *Rhyssota* | 11111 01111 010000 011 |
| *Dendrotrochus* | 11010 01101 000000 011 |
| *Antinous* | 11110 01101 000000 011 |
| *Kaliella* | 11110 01100 000000 011 |
| *Chronos* | 11110 01101 000000 011 |
| *Orpiella* | 11110 01101 001000 011 |
| *Nesokaliella* | 00110 00000 001000 0?1 |
| *Liardetia* | 00010 11000 110000 101 |
| *Louisia* | 00110 11000 110000 101 |
| *Euconulus* | 00010 11000 110000 101 |
| *Afroconulus* | 10111 01001 110000 101 |
| *Guppya* | 10110 11000 110000 101 |
| *Ernstia* | 10110 11000 110000 101 |
| *Aegopinella* | 11110 00000 000010 000 |
| *Gastrodonta* | 01011 00000 000111 000 |
| *Zonitoides* | 01011 00000 000111 000 |
| *Trochomorpha* | 01100 11000 010000 101 |

## ACKNOWLEGEMENTS

I am very grateful to B. Hausdorf for his constructive comments and suggestions on phylogeny of these confusing snails.

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# MINUTE VENERIDAE AND KELLIELLIDAE FROM THE RED AND ARABIAN SEAS WITH A REDESCRIPTION OF *KELLIA MILIACEA* ISSEL, 1869.

P. GRAHAM OLIVER[1] & MARTIN ZUSCHIN[2]

*Abstract* Kellia miliacea *Issel, 1869 is revised and reallocated to the genus* Alveinus. *This is only the second Recent species of a genus which is primarily represented in the Tertiary. This species is recorded from the Arabian Sea for the first time. Two minute venerids, one co-occurring with* A. miliaceus, *are described and placed in the genus* Microcirce. Microcirce dilecta *(Gould, 1861) was described from Japan and is recorded from the Red Sea for the first time.* Microcirce *consternans is described as new but was previously illustrated under the erroneous names of* Gouldia minima *var* triangularis *and* Pauliella miliacea.

*Key words* Veneridae, Kelliellidae, Red Sea, Arabian Sea, *Alveinus, Microcirce*

## INTRODUCTION

Minute veneriform bivalves were frequently found in the shell material collected by Zuschin from the Bay of Safaga, Red Sea and some were referred to the genus *Microcirce* Habe, 1951 (Zuschin & Hohenegger, 1998) while others were regarded as juveniles of other venerid genera such as *Pitar* and *Lioconcha.* Similar shells were present in samples from off Muscat, Oman collected by Don Bosch and living examples were present in samples taken for impact studies in the Arabian Gulf. The shells had been subject to taxonomic investigation and morphological analysis by the present authors when illustrations representing part of this series were published by Hoenselaar & Dekker (1998) under the name of *Pauliella miliacea* (Issel, 1869). The latter authors, however, did not comment on the discrepancy between Issel's description of *Kellia miliacea* and their own material and it was this discrepancy that inhibited Zuschin and Hohenegger (1998) from adopting the species name of *miliacea* for their material referred to *Microcirce* sp.

As a result, a confusing and contradictory situation arises about the status of *Kellia miliacea*, the generic and family affinities of this taxon and the variation and number of taxa present in the Arabian region. This paper attempts to clarify the situation by referring to the type series of *Kellia miliacea*, a shell morphology analysis and by examining anatomical characters.

## KELLIELLIDAE

### *Kellia miliacea* Issel, 1869
### Lectotype Designation

Only by examining the type material (originally three specimens) can the exact nature of this taxon be defined as the original description is incomplete and the figures very poor. The dentition was described from the right valve only and as having two cardinals and single anterior and posterior laterals but there is no mention of the ligament form. At the time of description the nominal generic taxa available were limited and Issel's placement in *Kellia* could simply be a result of this, for his illustrations are quite unlike the true *Kellia* that he may have been familiar with from the Mediterranean.

The bulk of Issel's collection is now housed by the Museo Civico Giacomo Doria in

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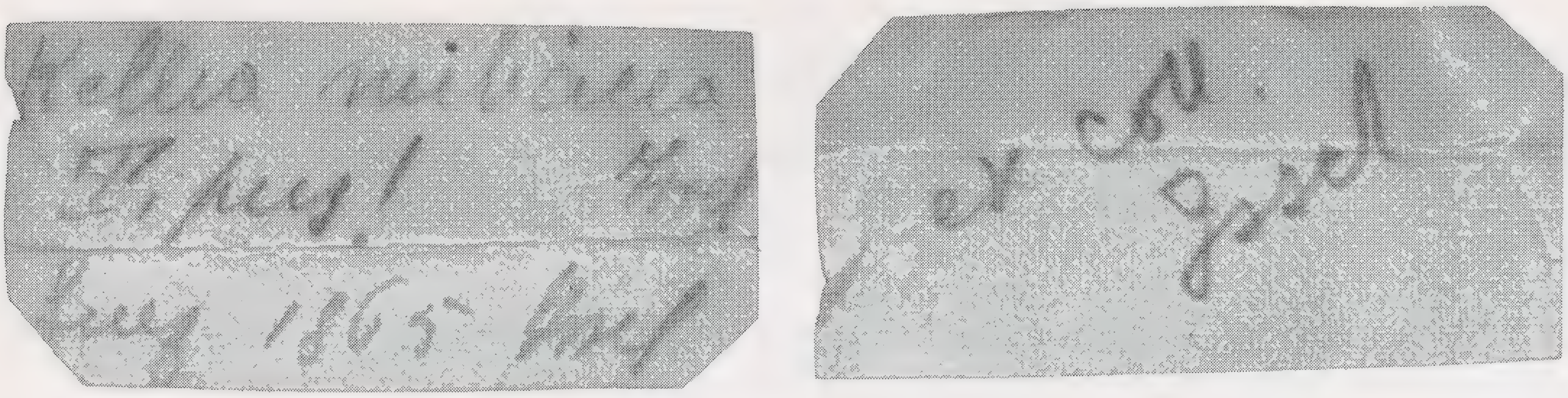


Kellia miliacea
Tipus! [illegible]
Suez 1865 Issel

ex coll
Issel

**Fig. 1** Original label from syntype series located in the National Museum of Wales (magnified)

Genoa but enquiries there were negative with no material present under that name. In the Melvill-Tomlin collection in the NMW, Cardiff is a single lot consisting of 2½ valves labelled *"Kellia miliacea* Tipus!, Suez, 1865, Issel" and on the reverse in Tomlin's handwriting, "ex coll Issel". The origin of this lot is obscure and we cannot say whether it was acquired by Melvill or Tomlin. Issel died in 1892 and could have corresponded with Melvill. Alternatively Tomlin may have acquired this at a later date through a purchase or exchange. We have sent a copy of the label (Fig. 1) to Genoa for confirmation and there is agreement that the label is authentic. The NMW lot can therefore be considered as having syntype status but it clearly consist of two distinct species.

Valve "A" is a right valve of a small suboval form with an internal, oblique resilium; a single peg-like cardinal and lateral indentations of the dorsal margins adjacent to the hinge plate. This valve is inseparable from *Scacchia elliptica* (Scacchi, 1831), a Mediterranean Erycinidae.

Valves "B" and "C" are a pair but valve "C" is a fragment in which only the anterior half is present. They are ovate trigonal in outline; have a deep pit just behind the beaks indicating an internal ligament.

The left valve possesses a single S-shaped cardinal complex alaigned parallel to the margin and anterior to the ligament pit. A marginal groove runs from a point adjacent to the tooth to approximately 1/5 the way down the edge, where it interrupts the margin. This interruption is expressed externally by an incised lunule groove. The remainder of the margin is simply bevelled.

The right valve bears a large pseudocardinal projecting from the lower margin of the hinge plate, above it lies a socket and above that there is a minute projection in a true cardinal position. Anterior to the teeth is a marginal ridge corresponding to the groove in the LV. The remainder of the margin especially posteriorly is distinctly grooved.

The generic position of this shell is obscure but has affinity to the Kelliellidae and will be discussed below.

The problem at hand, however, is which shell does Issel (1869) actually describe, one of the above or one now lost? His description is incomplete and the diagnostic hinge is described only from the "RV". This is also questionable as in the original figures the valves are labelled wrongly, the internal view is of the RV and not the LV as indicated. Alternative hypotheses are available.

**1.** The figures and description refer to the *Scacchia* valve.

This is least warranted as the outline of the figures show no indication of the dorsolateral indentations typical of *Scacchia.* Furthermore this species has so far not been recorded from the Red Sea but is known from throughout the Mediterranean.

**2.** Assuming that the figure labelling is an error and that the hinge description applies to the internally figured shell.

The "due dentini cardinali divergenti" two divergent cardinal denticles could be the divergent margins of the ligament fossa of valve "C". Note that dentini is a diminutive indicating that these teeth are very small. The anterior lateral with the associated socket could be the large pseudocardinal in valve "C". The "minute and little evident" posterior lateral remains a mystery. The figure (Fig. 2) shows a distinct triangular notch in the hinge plate behind the beak and is indicative of the ligament fossa of valves "B" and "C".

From the syntypes, the best fit to the type description is for valves "B" and "C" and thus referable to the Kelliellidae.

**3.** A further option is to consider the taxon described by Hoenselaar and Dekker and take the opinion that the syntype series is incomplete but at one time included this form.

The hinge of this species is strong and the RV has three cardinals of which only the anterior is quite small. There is a deep anterior lateral socket but again no trace of any posterior lateral.

It should be noted that in other veneroid descriptions Issel uses "denti" for teeth and only in *K. miliacea* does he use "dentini". It seems unlikely that the large teeth of this taxon would be referred to as "dentini". The hinge plate of this taxon is thick and entire behind the beaks with no trace of an internal fossa.

The decision of this paper is therefore to fix the taxon *Kellia miliacea* to the valves "B" and "C" of the syntype series located in the NMW. As these valves are a pair they form the lectotype.

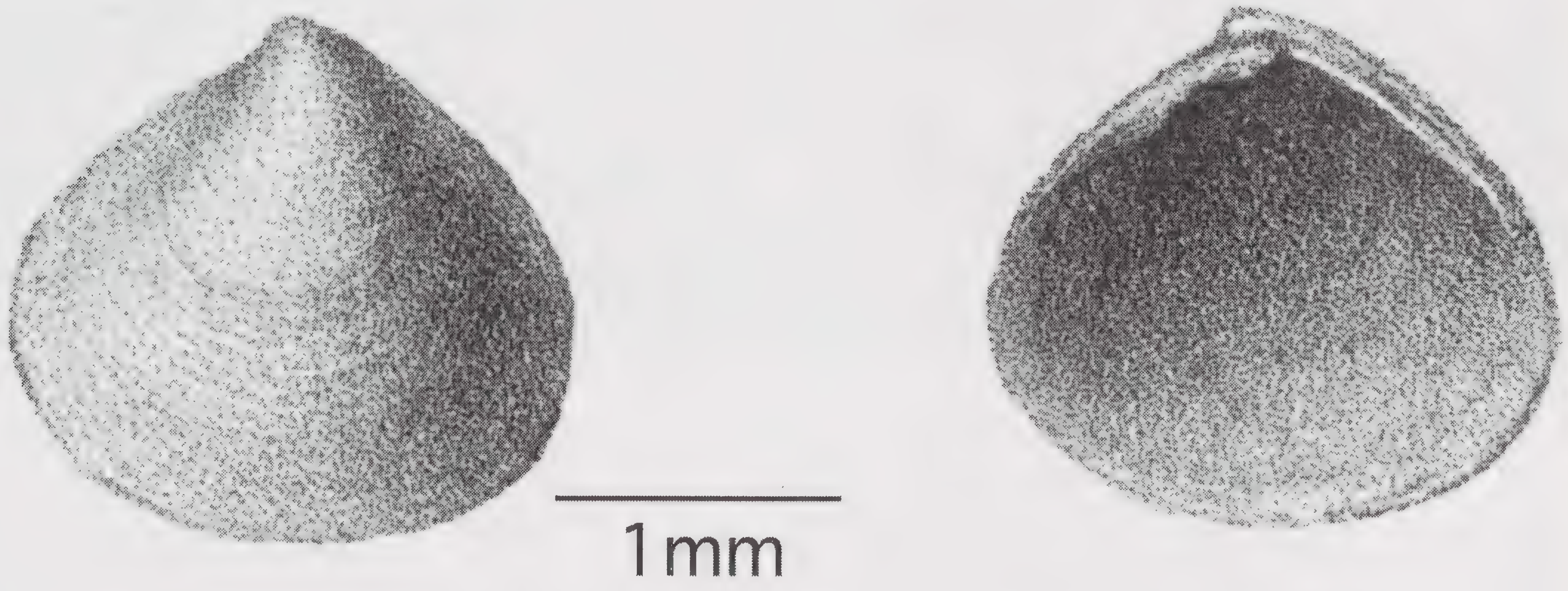


**Fig. 2** Original illustrations of *Kellia miliacea* from Issel, 1869 (magnified)

## REDESCRIPTION

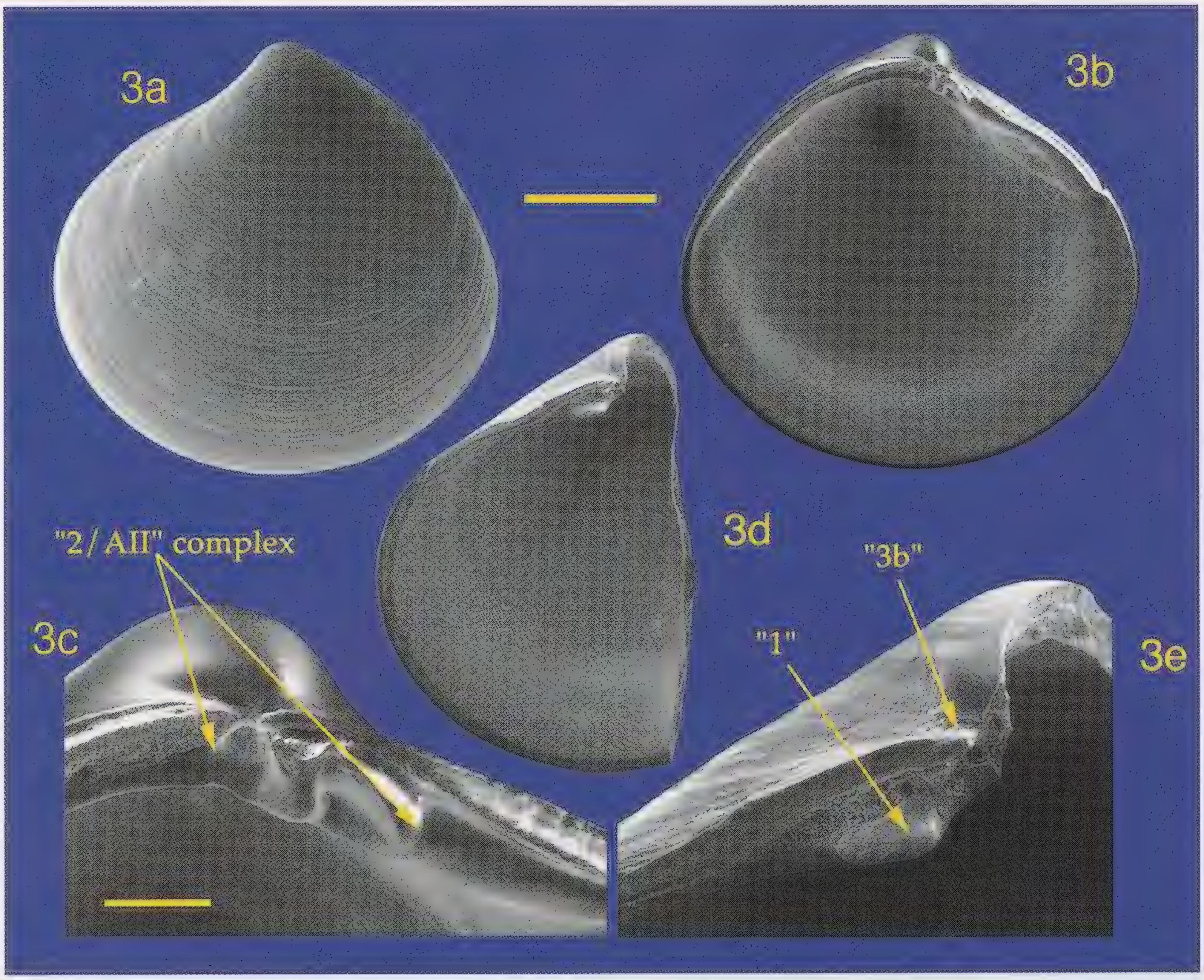
VENEROIDA
ARCTICOIDEA
KELLIELLIDAE

Genus ***Alveinus*** Conrad 1865
Type species *Alveinus minutus* Conrad, 1865

***Alveinus miliaceus*** (Issel, 1869)
Figs 3a–e, 4a–b, 5, 6, 7a–b, 8a–b

*Kellia miliacea* Issel, 1869: 87, Pl. 1, Fig. 11
non *Pauliella miliacea* (Issel, 1869) - Hoenselaar & Dekker, 1998: 206, Figs 1-6.

*Lectotype* NMW. 1955.158. 02269 Ex coll Issel.

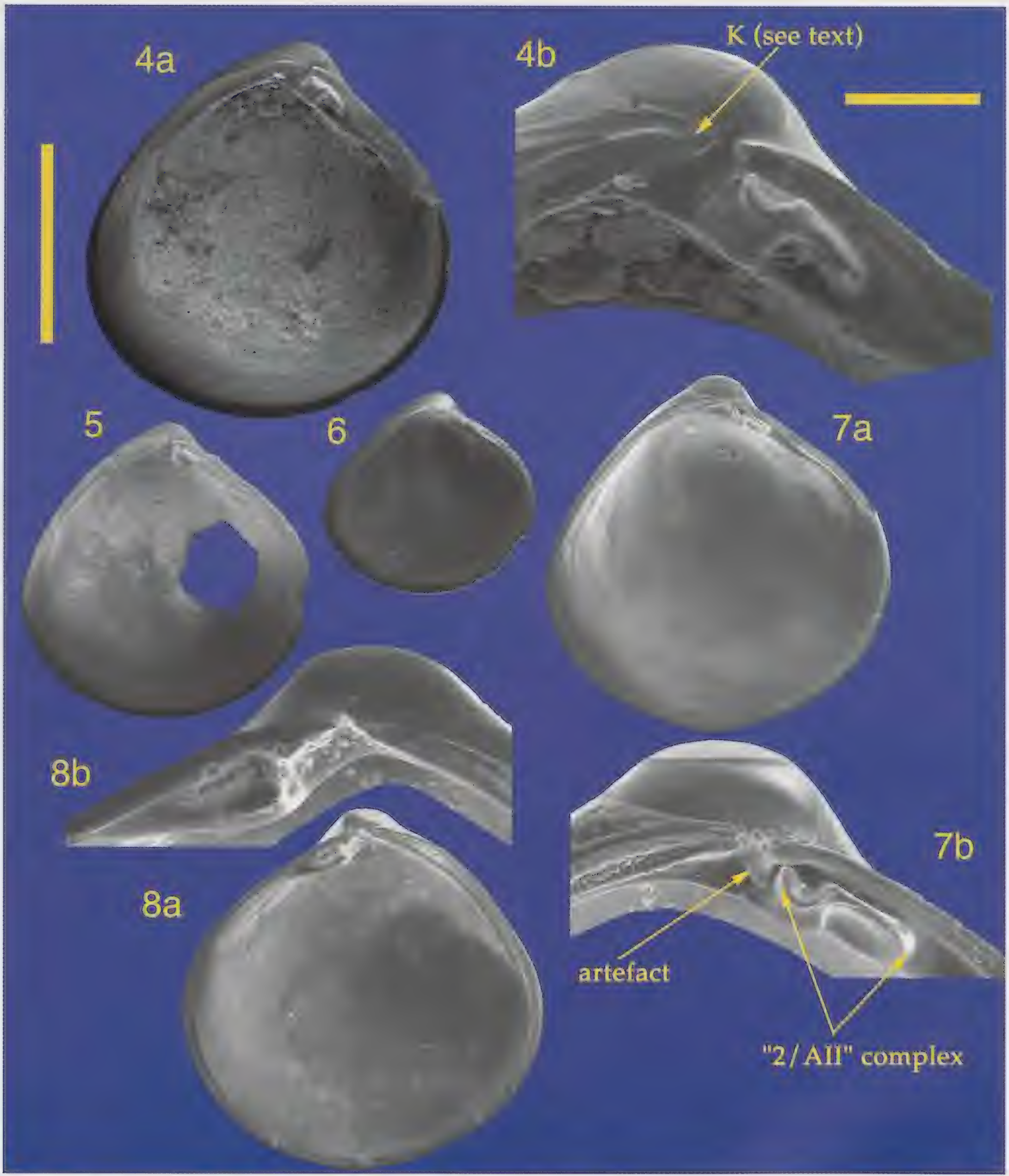


**Figs 3a–e** *Alveinus miliaceus* (Issel, 1869), Lectotype, NMW. 1955.158.02269. **3a** external of LV **3b** internal of LV **3c** detail of horizontal S-shaped pseudocardinal **3d** internal of RV fragment **3e** detail of hinge of RV. Scale bar for 3a, b, d = 0.5mm; for 3c, e = 200µm.

*Material examined* 1sh+4v Off Seeb, Oman, 23°37′N 58°36′E, 50–100ft, leg. D. Bosch, coll. Khamees, NMW.Z.1999.101.01. 5v, Bay of Safaga, Egypt, IPW #94/3/a, 26°47.47′N 33°56.80′E, 23m, muddy sand.

*Type locality* Gulf of Suez.

*Description* Maximum size 2 mm. Shell proportionately solid. Equivalve. Equilateral, outline ovate trigonal, posterior dorsal slope long and less curved than anterior. Escutcheon indistinct. Lunule large, elongate oval and demarcated by an incised line. Beaks small, slightly prosogyre. Sculpture of fine incremental, concentric lines only. Hinge weak, hinge plate narrow and interrupted below umbo by a small ligament fossa. Left valve hinge with a single, S-shaped cardinal complex aligned parallel to the margin, this tooth has a distinct socket on its anterior ventral margin and a narrow sinus running into the beak on its dorsal posterior edge. There is a submarginal groove running from the cardinal area to about one fifth of the way down the anterior margin where it interrupts the edge in a small notch. This notch is represented externally by the incised lunule line. The margin is bevelled especially on the posterior. Right valve with a large pseudocardinal on the ventral margin of the hinge plate; above is a deep socket and on the edge below the beak is a small cardinal peg. Anterior to the teeth is a narrow ridge corresponding to the groove in the LV. Elsewhere the margin is grooved, into which the



**Figs 4–6** *Alveinus miliaceus* (Issel), Safaga, Egypt, Red Sea.
**Figs 7–8** *Alveinus miliaceus* (Issel), Off Muscat, Oman, Arabian sea. Right scale bar = 1mm for complete valves; left = 200μm for hinge details.

bevelled edge of the LV fits. Muscle scars weak and pallial line appears to be entire.

Shell colour white.

*Remarks* The generic placing of this taxon is based on shell characters alone and the hinge in particular. The incomplete veneroid hinge is typical of some Arcticoidea and Glossoidea. These groups also often display marginal grooves but that is also seen in the Veneroidea. Of described taxa the general form is similar to *Alveinus, Lutetia* (Conrad, 1865; Dall, 1900; Harris, 1920) and *Pauliella*. On hinge characters *Pauliella* has too many teeth, 3 cardinals in each valve along with anterior and posterior lateral lamina. *Lutetia*

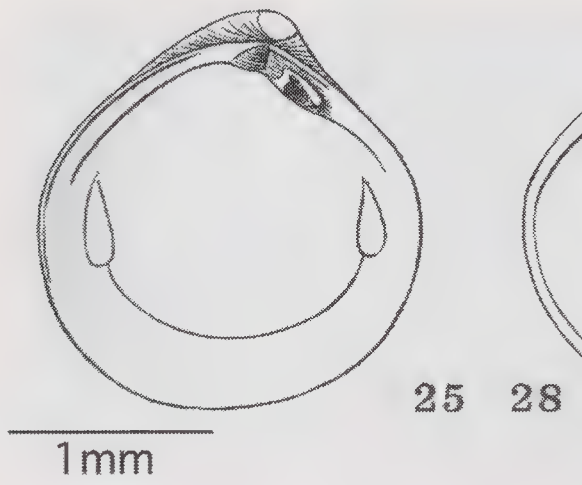


**Fig. 9** *Alveinus rotundatus* Dall, 1900 Chipola formation Florida, Oligocene, from Dall 1900.

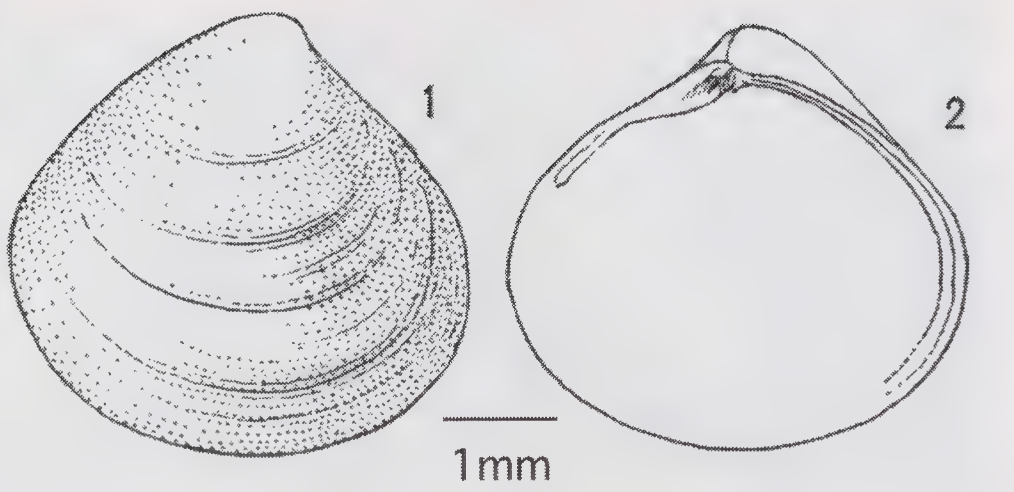


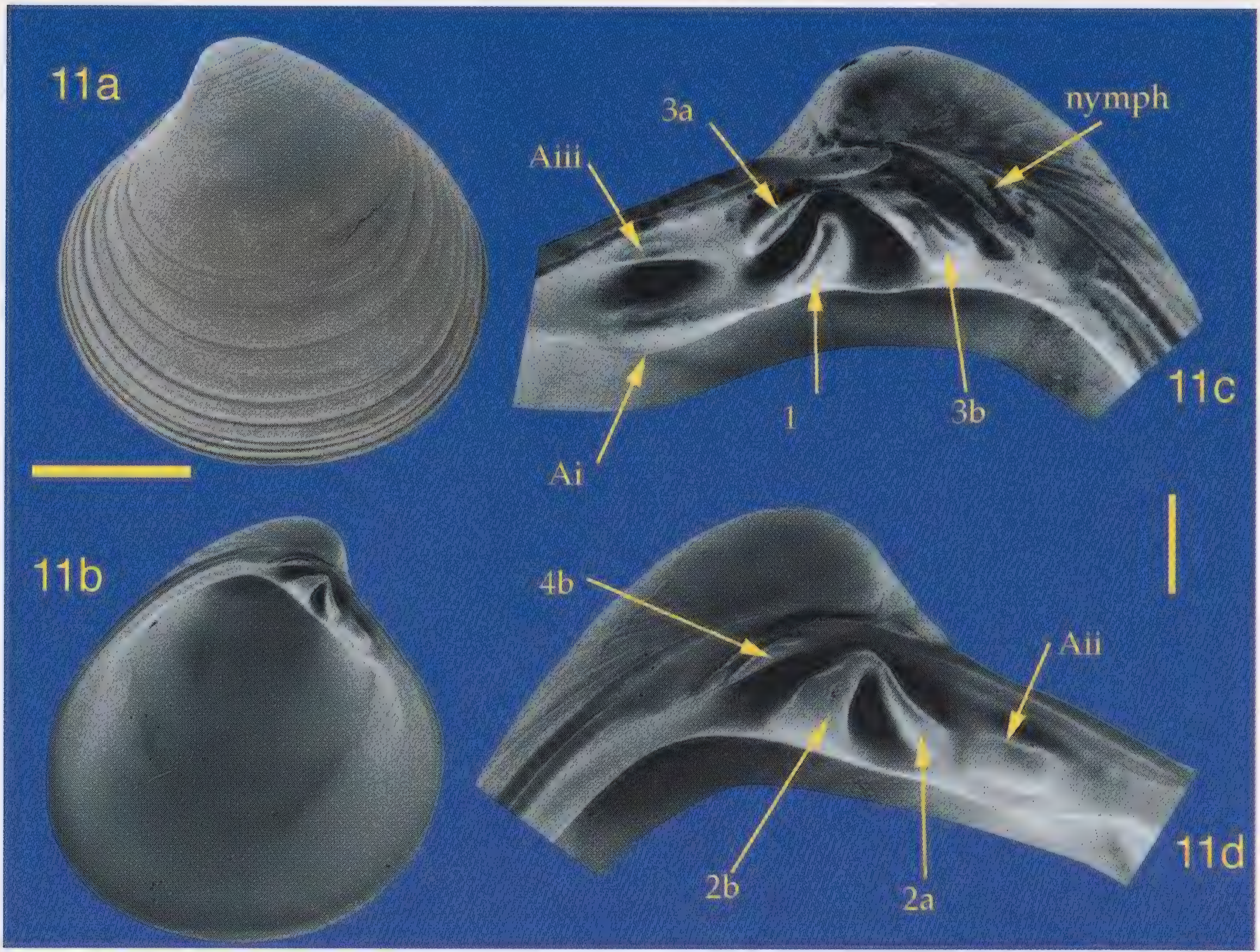
**Fig. 10** *Alveinus ojianus* (Yokoyama, 1927), Japan from Habe, 1977.

*(Lutetia)* and *L. (Spaniodontella)* have an external ligament and again three teeth in each valve. *Alveinus* (Fig. 9) has a similar dentition and ligament fossa except that the upper tooth in the RV is larger and the tooth in the LV with a weaker posterior dorsal portion. The marginal groove is also present in *Alveinus.*

*Alveinus* has until now been recognised from the Tertiary (Upper Eocene-Miocene) of N. America and from the Tertiary - Recent of Japan. The related *Lutetia* is widespread in N. American, European and SW Asian strata of Tertiary age (Keen in Moore, 1969).

The only other Recent species is *Alveinus ojianus* (Yokoyama, 1927) a species originally described from the Tertiary of Japan but subsequently recorded living by Habe (1950) in Tanabe Bay and is subsequently cited by Habe (1977), Higo & Goto (1993), Bernard *et al.* (1993) and Higo, Callomon & Goto (1999). The generic name is incorrectly spelled throughout as *Alvenius.* The illustrations (Fig. 10) show a more rounded shell with a weaker dentition in the RV and shows little evidence of the ligament fossa. This species may be better referred to *Lutetia (Spaniodontella)* and is not considered conspecific with *A. miliaceus.*

The affinities of the genus *Alveinus* are according to Keen (1969) with the Kelliellidae but the hinge structures found within that family are variable enough to suggest polyphyly. *Kelliella* has a more complex dentition; LV with an S-shaped tooth and a small peg beneath the beak, RV with and anterior projectiong lateral and a cardinal complex consisting of an anterior laminar shelf and a median projecting partly bifid peg (see Fig. 16 in Warén, 1989). *Pauliella* is described by Keen (1969) as having 3 cardinals, 2 posterior laterals and 3 anterior lateral lamina and *Allopagus* as having only single cardinal teeth in each valve. Keen rarely attempts homology and the modified Bernard notation (Cox, 1969) is not applied to the genera mentioned here. If we examine the ontogeny of veneroid hinges (Cox, 1969; Salas and Gofas, 1998) we could regard the S-shaped tooth of *Alveinus* as either a modified 2 or modified 2, AII complex where there is no 2a, 2b or anterior lateral development. There is no homologous peg (position K in Fig 4b) in *Alveinus* equivalent to that seen in the LV of *Kelliella* and this tooth is also absent from venerids. [The apparent peg seen in Fig. 7b is an artefact caused by sediment remains deep in the ligament fossa.] In the RV the large laminar tooth is in the 1 position and the minute peg adapically to it is in the 3b position. One interpretation of this comparison would be to suggest that *Alveinus* has venerid affinities rather than with *Kelliella* and that the hinge is basically a neotenous venerid type. However, the *Alveinus* hinge can be derived from *Kelliella* by the loss of the RV peg and lack of development of the 3b complex. In the modified 2a,2b complex of *Neolepton* Salas & Gofas, 1998) the two elements remain recognisable but in *Alveinus* the the excavated dorsal surface of the more median prtion is not seen in any of the venerid hinges but is more reminiscent of the equivalent tooth of *Kelliella.* Only with reference to the anatomy of *Alveinus* can we begin to resolve this issue and until that is possible *Alveinus* is left within the Kelliellidae.



**Figs 11a–d** *Gouldiopa australis* (Angas, 1865) New South Wales, Australia. NMW 1955.158. Scale bars a & b = 1 mm, c & d = 100µm.

## VENERIDAE

The number of shells of *Alveinus miliaceus* found in our samples was very small compared to the numerous valves of small venerids. Many of these venerids were juveniles of larger species of *Circe, Lioconcha, Pitar, Callista* and *Tapes* but at some sites most were adults of small subtrigonal to trigonal forms similar to that figured by Moazzo (1939) as *Gouldia minima* var *triangularis* and by Hoenselaar and Dekker (1998) as *Pauliella miliacea* and referred to by Zuschin and Hohenegger (1998) as *Microcirce* sp.

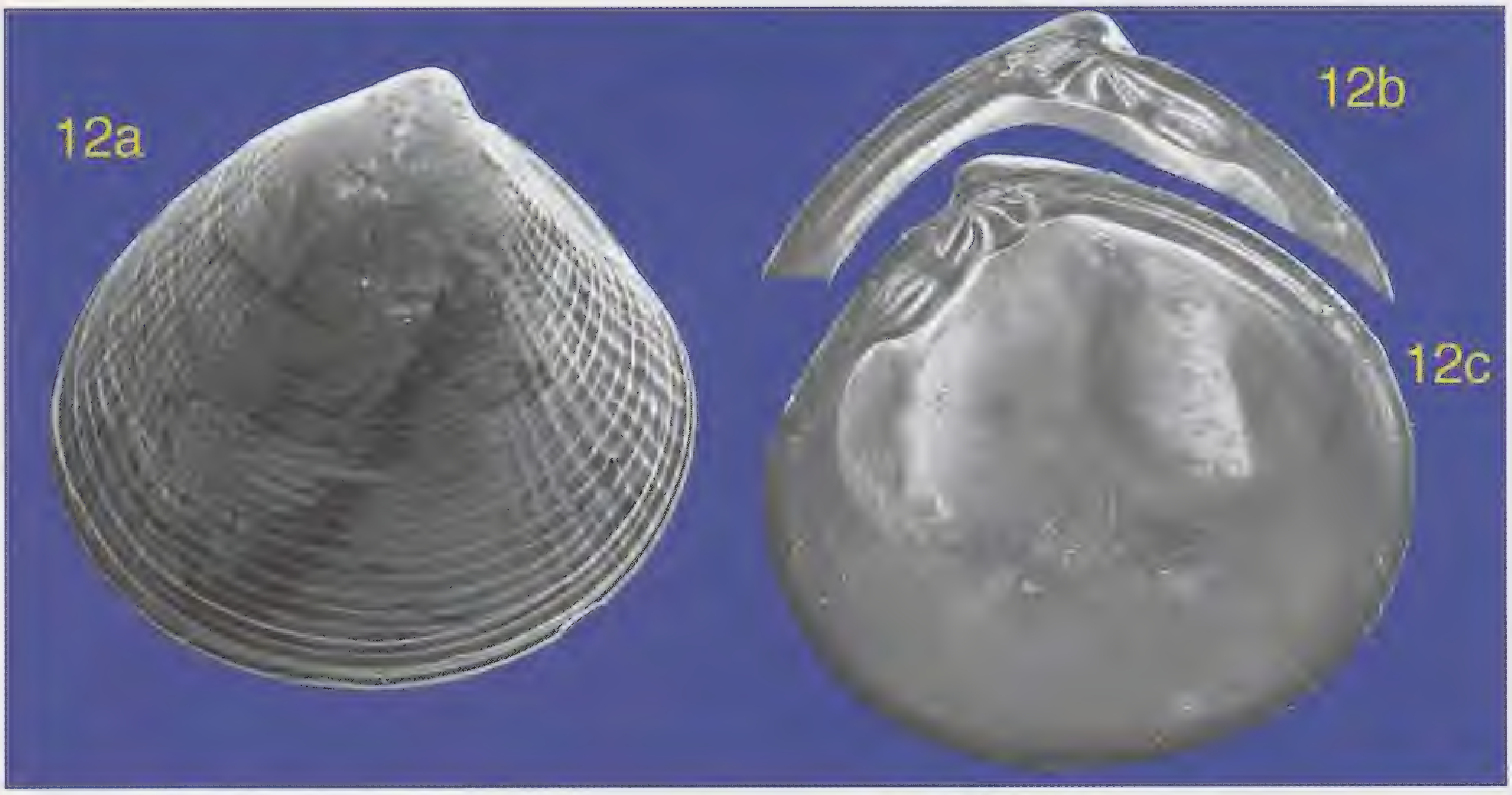
The decision above on the lectotype designation of *Kellia miliacea* precludes use of this name for any of the venerids.

The taxa described below have totally typical venerid hinge structures, three cardinals in each valve and a well developed anterior lateral. The anatomy as shown is also typical of venerids. From all described genera this paper concludes that *Microcirce* is appropriate.

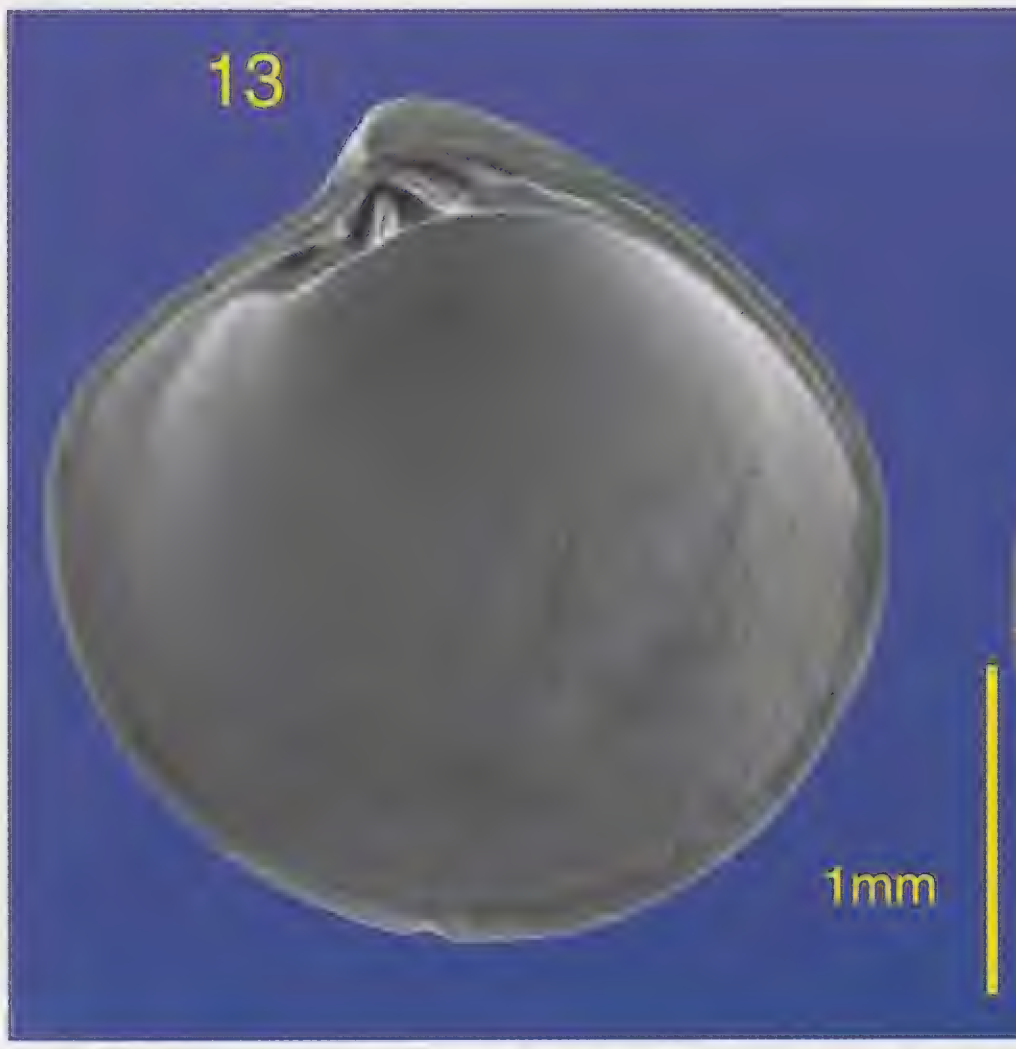
### Genus **Microcirce** Habe, 1951

Type species *Meretrix gordonis* Yokoyama, 1927 = *Gouldia dilecta* Gould, 1861

*Generic diagnosis* Minute but solid, subovate – trigonal, sculpture smooth - weakly concentric, hinge strong with well developed anterior laterals and three cardinals in each valve, prominent anterior and posterior marginal grooves present, posterior pallial line straight but not forming a sinus.



**Figs 12a-c** *Gouldia (Dorisca) melvilli* (Lynge), Singapore. NMW.1955.158. Scale bar = 1mm.



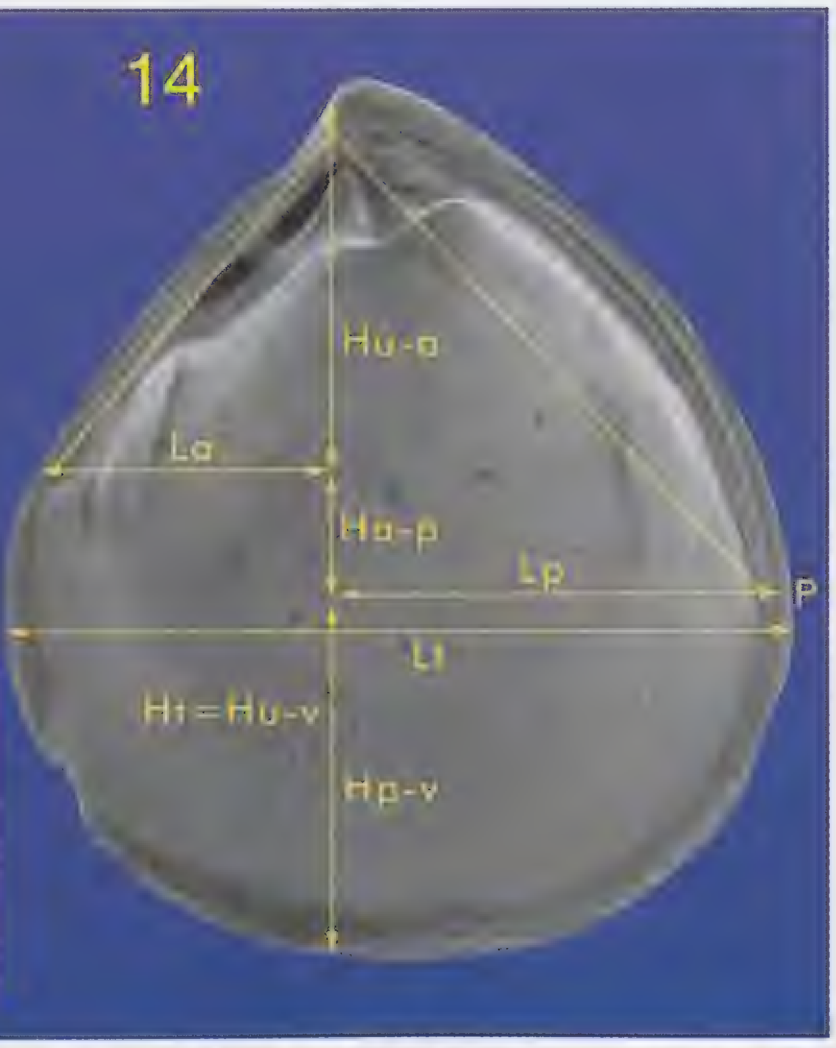


**Fig. 13** *Lioconcha ornata* Dillwyn, juvenile, Bay of Safaga. **Fig. 14** Measurements used in analysis of shape of *Microcirce* shells. Fixed points– **U** umbo: **A** end of anterior marginal groove: **P** end of posterior marginal groove: **V** ventral margin. Angle measurements– Anterior apical angle = AUV: Posterior apical angle =VUP: Apical angle = AUP.

*Remarks* Few genera of the Circiinae lack radial sculpture especially on the umbonal regions. *Circe* has prominent dichotomous riblets on a very flattened umbo, *Gafrarium* has dichotomous sculpture overall and *Gouldia* most often has weak radial sculpture. Some *Gouldia* species, the European *G. minima* (Montagu, 1803) for example, lack radial sculpture but are compressed. Typical of these small *Gouldia* forms is *G. (Dorisca) melvilli (Lynge, 1909)*and the illustrations show the distinctive sculpture but the great similarity in hinge form (Figs12a–c).

*Microcirce* Habe, 1951, although regarded as a subgenus of *Circe* (Keen in Moore, 1969;

Vaught, 1989), lacks any radial sculpture, is not compressed and is similar in most ways to the Red Sea material. Other small species are found in *Gouldiopa* Iredale, 1924 (Figs11a–c) which despite being placed as a subgenus of *Gouldia* (Keen in Moore 1969) is not compressed and lacks any radial sculpture. We believe that *Microcirce* and *Gouldiopa* probably do not warrant separation but we are reluctant to synonymise outside a wide ranging subfamily revision of the Circiinae. *Gouldiopa* takes priority over *Microcirce* but as the Red Sea species are most similar to *M. dilecta* we use *Microcirce*. The only other genus lacking any radial sculpture is *Circenita* and there was concern that *Microcirce* may simply represent juveniles of *C. callipyga* (Born, 1778) a large and often common Red Sea species. *Circenita callipyga*, however, is not found in the Bay of Safaga and it seems unlikely that juveniles would exist in such numbers. Small specimens from other parts of the range are subovate and not trigonal and are therefore also morphologically distinct.

Although all Circiinae lack a pallial sinus the Pitarinae genus *Lioconcha* also lacks a sinus. *Lioconcha ornata* (Dillwyn, 1817) is frequent in the quantitative bulk samples but the juveniles are subovate and not at all trigonal (Fig. 13).

### ***Microcirce dilecta*** (Gould, 1861)
Figs 15a–d, 16a–c

*Gouldia dilecta* Gould, 1861: 32.
*Gouldia dilecta* Gould, 1861– Johnson, 1964: 68, pl. 29, fig. 4 [holotype figured].
*Meretrix gordonis* Yokoyama, 1927: 429.
*Microcirce dilecta* Gould, 1861– Habe, 1977: 254, pl. 53, figs 19-21. (Note that these figs are labelled erroneously and have been exchanged with figures 14-16 which are *Costellipitar chordatum*).
*Pauliella miliaris* (Issel)– Hoenselaar & Dekker, 1998: 206, in part, [not figs 1-6].

*Holotype* In USNM, 64077.

*Material examined* Japan: 27spec., Yellow Sea 33°15.5′N 129°12′E, Leg. Capt. St. John, HMS Sylvia, BM(NH) 1878.10.16.193. Red Sea, Bay of Safaga: 50v, IPW#C 1/3. 50v, IPW#B 9/1.

*Type locality* Kagoshima, Japan.

*Measurements* (see Table 1).

*Shell* Minute to 4 mm. Equivalve. Solid. Not compressed. Beaks slightly prosogyre. Subovate with beaks almost central, slightly longer than high. Anterior and posterior margins sloping, gently merging with rounded ventral margin. Lunule margin less curved than posterior margin, not concave, lunule weakly defined. Sculpture weak of low concentric ridges only. Hinge moderate: rv with 3 cardinal teeth; posterior and median larger, triangular and radiating from beak; anterior narrow, laminar, parallel to shell margin and in line with upper lateral, forming a pseudo lateral socket with median cardinal; paired anterior lateral teeth prominent forming a socket; LV with 3 cardinal teeth; posterior small laminar, median large, triangular, anterior long, laminar; anterior and median joined dorsally and forming a triangular socket; anterior lateral large and in line with anterior cardinal. Ligament small on a deeply sunken nymph below and behind the beaks. Marginal grooves and ridges present: RV with a lunule margin ridge extending beyond the end of the hinge plate; posterior with a groove extending to the mid point; lv as rv but anterior with a groove and posterior with a ridge. Ventral margins

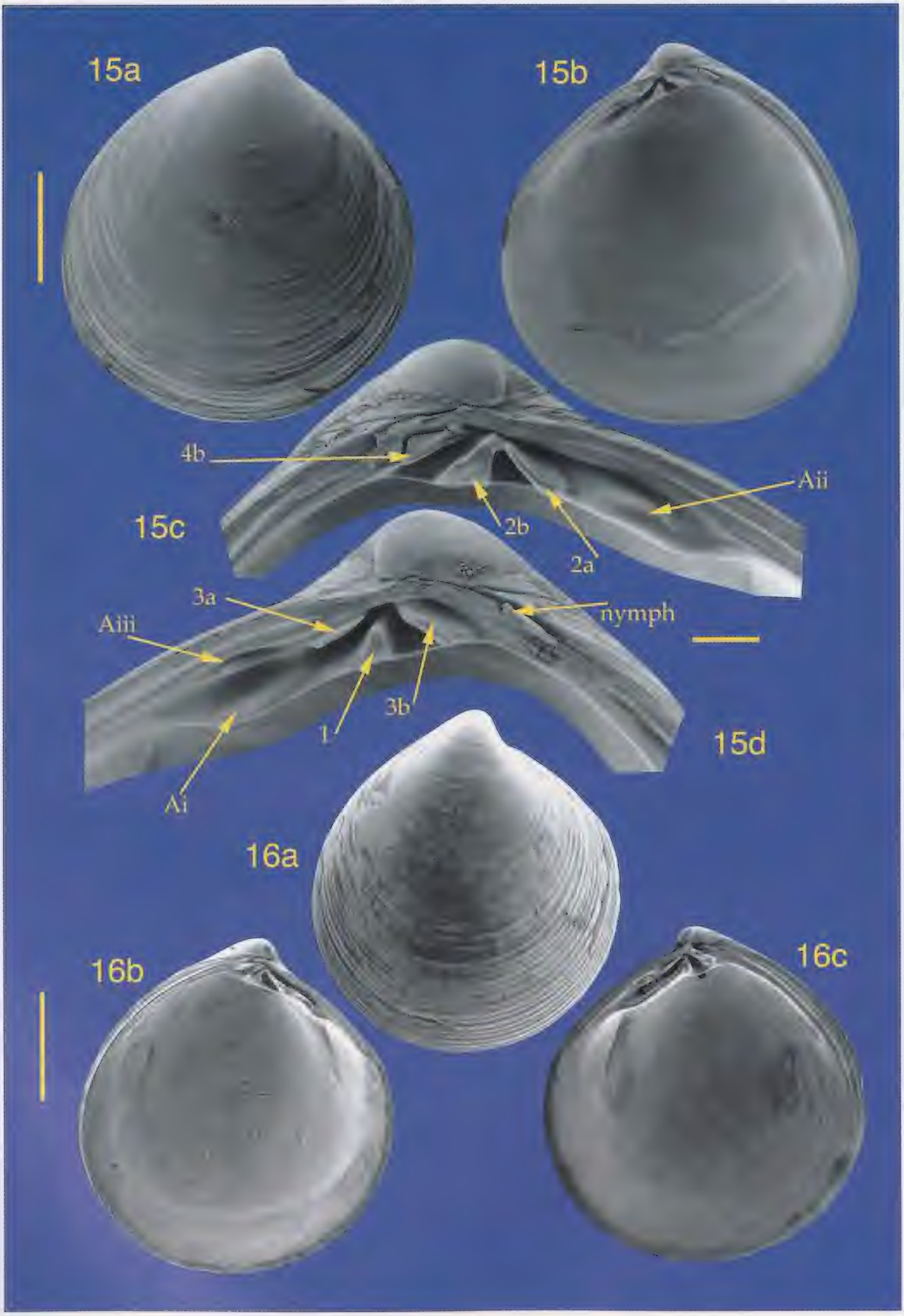
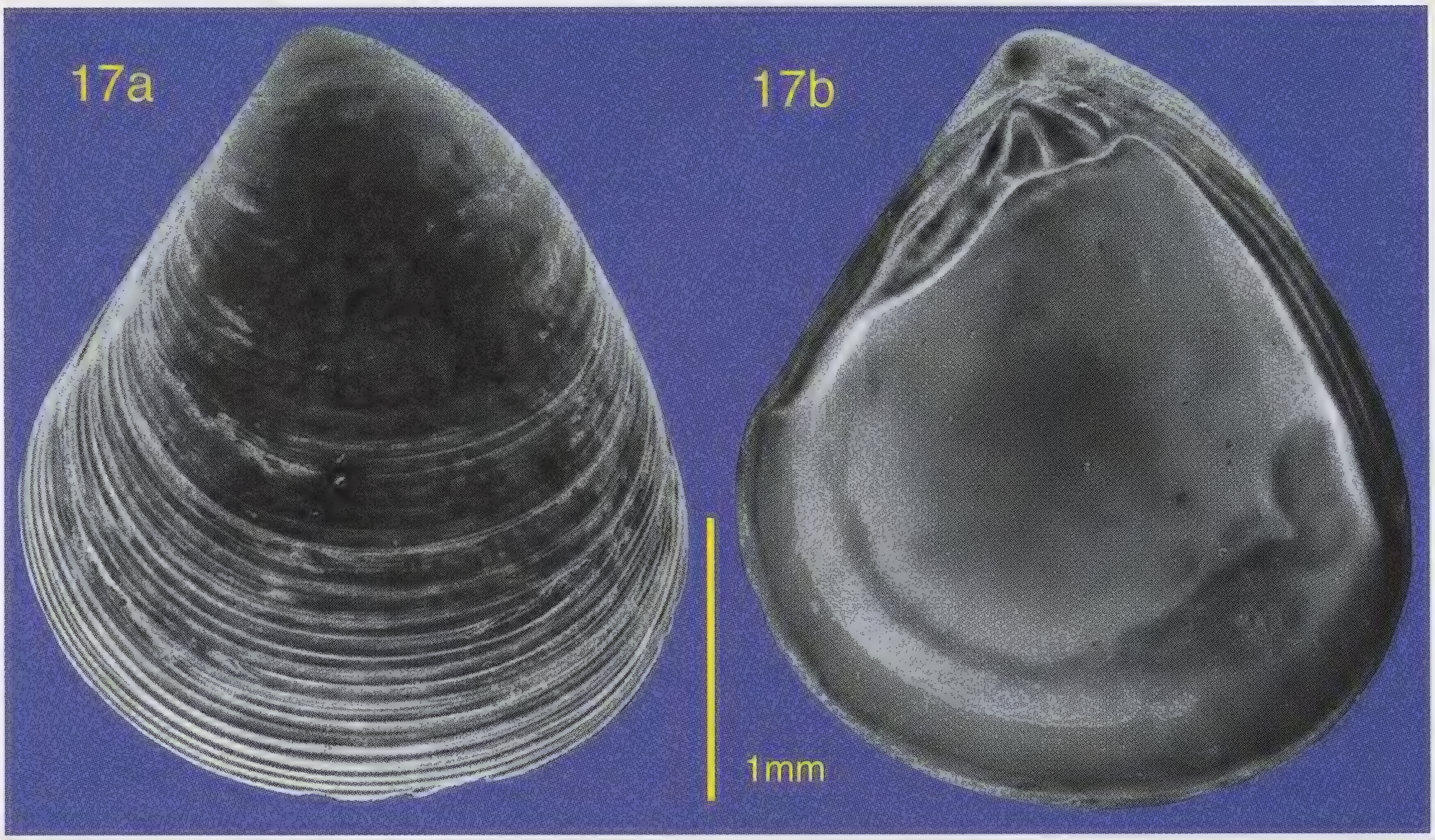

15a
15b
4b
Aii
15c
2b
2a
3a
nymph
Aiii
3b
1
15d
Ai
16a
16b
16c

TABLE 1
Measurements and ratios of *Microcirce* species

| | Mean | SD | Min | Max | Count |
|---|---|---|---|---|---|
| **Lt** | | | | | |
| *dilecta*/Red Sea | | | 1.7 | 3.7 | 31 |
| *dilecta*/Japan | | | 3.0 | 3.9 | 15 |
| *consternans*/Red Sea | | | 1.5 | 3.3 | 40 |
| *consternans*/Muscat | | | 1.5 | 2.7 | 30 |
| **La** | | | | | |
| *dilecta*/Red Sea | | | .68 | 1.5 | 31 |
| *dilecta*/Japan | | | 1.24 | 1.6 | 15 |
| *consternans*/Red Sea | | | .58 | 1.1 | 40 |
| *consternans*/Muscat | | | .56 | 1.06 | 30 |
| **Lp** | | | | | |
| *dilecta*/Red Sea | | | 1.7 | 3.7 | 31 |
| *dilecta*/Japan | | | 3.0 | 3.9 | 15 |
| *consternans*/Red Sea | | | 1.5 | 3.3 | 40 |
| *consternans*/Muscat | | | 1.5 | 2.7 | 30 |
| **Lt/La** | | | | | |
| *dilecta*/Red Sea | 2.43 | .15 | 2.2 | 2.94 | 31 |
| *dilecta*/Japan | 2.49 | .12 | 2.28 | 2.79 | 15 |
| *consternans*/Red Sea | 2.56 | .19 | 2.27 | 3.03 | 40 |
| *consternans*/Muscat | 2.57 | .15 | 2.31 | 2.92 | 30 |
| **Ht** | | | | | |
| *dilecta*/Red Sea | | | 1.5 | 3.1 | 31 |
| *dilecta*/Japan | | | 2.7 | 3.6 | 15 |
| *consternans*/Red Sea | | | 1.4 | 3.0 | 40 |
| *consternans*/Muscat | | | 1.4 | 2.5 | 30 |
| **Hu-a** | | | | | |
| *dilecta*/Red Sea | | | .37 | 1.22 | 31 |
| *dilecta*/Japan | | | .92 | 1.39 | 15 |
| *consternans*/Red Sea | | | .56 | 1.32 | 40 |
| *consternans*/Muscat | | | .51 | 1.13 | 30 |
| **Ht/Hu-a** | | | | | |
| *dilecta*/Red Sea | 2.96 | .36 | 2.34 | 3.9 | 31 |
| *dilecta*/Japan | 2.97 | .22 | 2.58 | 3.4 | 15 |
| *consternans*/Red Sea | 2.44 | .15 | 2.21 | 2.9 | 40 |
| *consternans*/Muscat | 2.37 | .14 | 2.05 | 2.7 | 30 |
| **Lt/Ht** | | | | | |
| *dilecta*/Red Sea | 1.12 | .03 | 1.07 | 1.17 | 31 |
| *dilecta*/Japan | 1.09 | .02 | 1.05 | 1.13 | 15 |
| *consternans*/Red Sea | 1.08 | .03 | 1.03 | 1.15 | 40 |
| *consternans*/Muscat | 1.05 | .03 | .99 | 1.11 | 30 |
| **Ant. Ap. Angle (AUV)** | | | | | |
| *dilecta*/Red Sea | 53.6 | 4.2 | 41 | 62 | 31 |
| *dilecta*/Japan | 50.1 | 2.4 | 46 | 55 | 15 |
| *consternans*/Red Sea | 45.6 | 3.3 | 38 | 52 | 40 |
| *consternans*/Muscat | 43.3 | 3.4 | 37 | 49 | 30 |

**Figs 15a–d** *Microcirce dilecta* (Gould), Japan, BM(NH). **a** right valve external. **b** right valve internal. **c** hinge detail in left valve. **d** hinge detail in right valve.

**Figs 16a–c** *Microcirce dilecta* (Gould), Bay of Safaga, Egypt. **a** right valve external. **b** left valve internal. **c** right valve internal. Scale bars = 1mm except for 15c & d =100µm.



**Figs 17a–b** *Microcirce consternans* n. sp. Off Muscat, Oman, Arabian Sea. Holotype. NMW.Z. 1999.101.02 Scale bar = 1mm.

smooth. Adductor scars not well defined, equal in size, ovate. Pallial line entire but becoming straight posteriorly instead of forming an indented sinus. Shell colour white.

*Habitat* Valves only have been taken from muddy sand with sea grass facies at depths of 40 to 48m. They are recorded from 10 to 300m in Japan (Habe, 1977).

*Distribution* *Microcirce dilecta* has not previously been recorded outside of Japanese waters. Its presence in the Red Sea suggests that it has a wide distribution in the Indo-Pacific but has not been reported due to its small size and easy confusion with juvenile venerids.

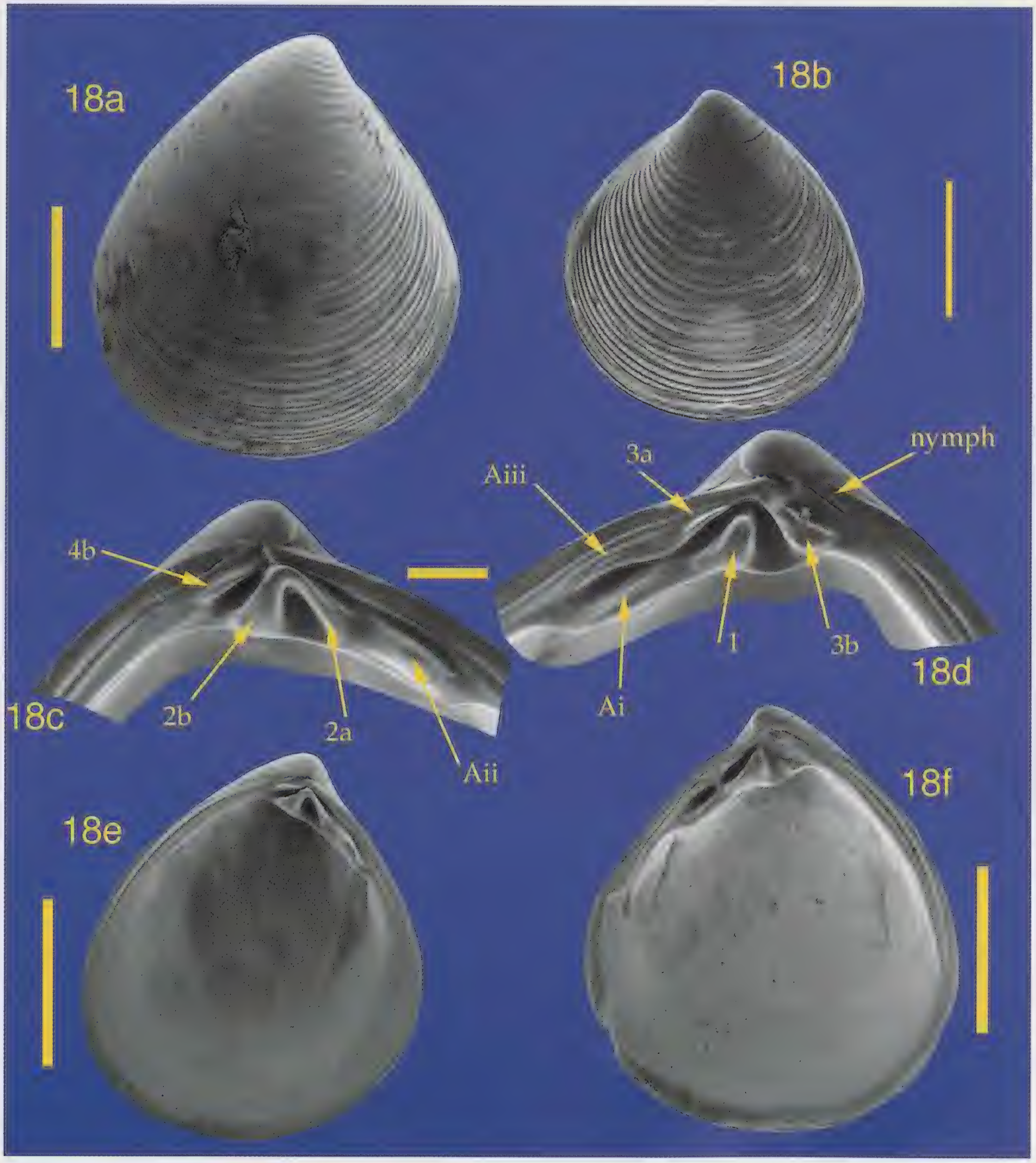
*Remarks* See under remarks for *M. consternans*, below.

**Microcirce consternans** n. sp.
Figs 17a–b, 18a–f, 19a–d, 20a–d

*Gouldia minima* var *triangularis* Montagu– Moazzo, 1939: 90, fig. 4.
*Microcirce* sp. – Zuschin & Hohenegger, 1990:229–254
*Pauliella miliaris* (Issel)– Hoenselaar & Dekker, 1998: 206, figs 1-6

*Holotype* One shell, Off Seeb, Oman, Arabian Sea, 100 feet depth, Leg. Khamees/Bosch, NMW.Z. 1999.101.02.

*Paratypes* 10v as Holotype in each, NMW.Z. 1999.101.03. & NHMW 90662
*Other material examined* Bay of Safaga, Egypt, Red Sea: 1sh + 92v, IPW#94/3/a. 150v, IPW#94/3/b. 131v, IPW#94/4/a. 67v, IPW#94/4/b. 18 spec. Qatar, Arabian Gulf, shallow water collected by diver, Leg. P. Garwood, NMW.Z. 1999.101.04. 5sh +4v, Persian Gulf, leg. Pelly, coll. Macandrew, UCZM. 30sh, Singapore, Coll Melvill-Tomlin,



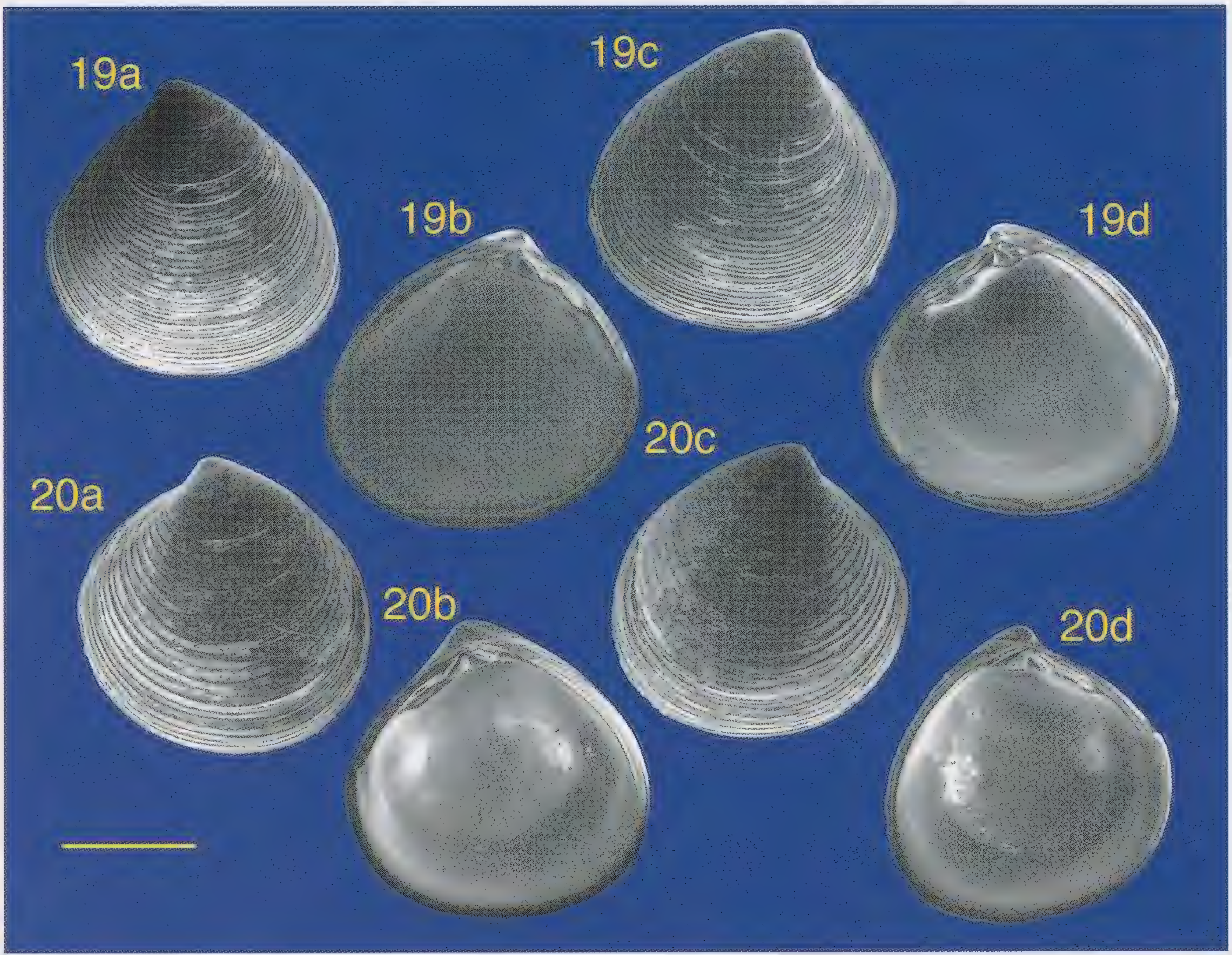
**Figs 18a–f** *Microcirce consternans* n. sp. Bay of Safaga, Egypt. Scale bars = 1mm except for c–d

NMW.1955.158.

*Type locality* Off Seeb, Oman, Arabian Sea.

*Measurements* Holotype L= 2.7 mm, H= 2.5 mm. others see Table 1.

*Shell* Minute to 3.3 mm. Equivalve. Solid. Not compressed. Beaks slightly prosogyre. Subovate–trigonal, generally slightly higher than long. Anterior and posterior margins sloping steeply, rather long, gently merging with rounded ventral margin. Lunule margin less curved than posterior margin, lunule weakly defined. Sculpture weak of



**Figs 19a–d** *Microcirce consternans* n. sp. Off Qatar, Arabian Gulf.
**Figs 20a–d** *Microcirce* cf. *consternans* n. sp. Singapore. Scale bar = 1mm.

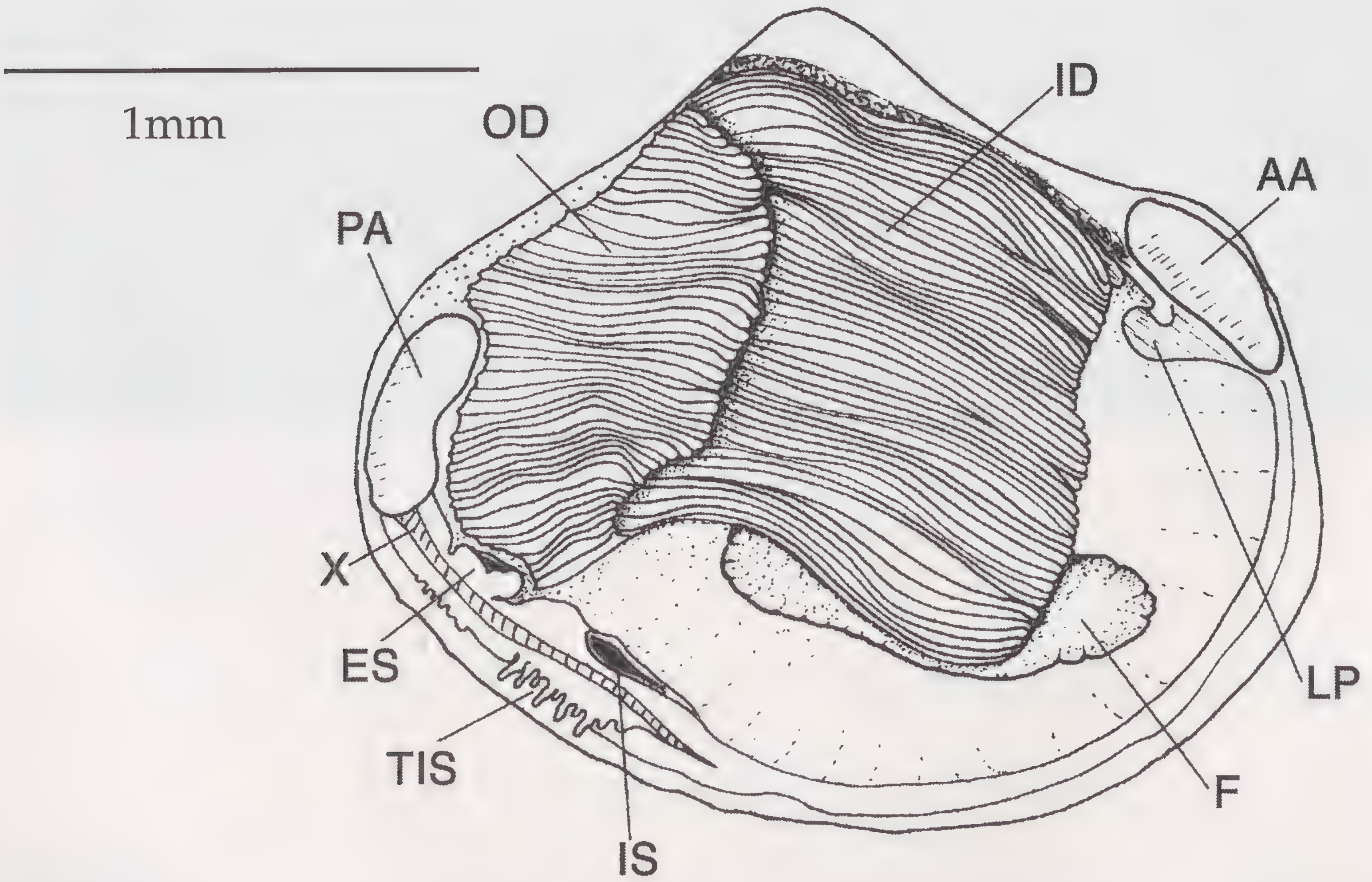


**Fig. 21** Gross anatomy of *Microcirce consternans*, Arabian Gulf. Abbreviations:- **AA** anterior adductor, **ES** exhalant siphon, **F** foot, **ID** inner demibranch of ctenidium, **IS** inhalant siphon, **LP** labial palps, **OD** outer demibranch of ctenidium, **PA** posterior adductor, **TIS** tentacles surrounding inhalant siphon, **X** cut area of fused mantle margins.

low concentric ridges only. Hinge strong: rv with 3 cardinal teeth; posterior and median large, triangular and radiating from beak; anterior narrow, laminar, parallel to shell margin and in line with upper lateral, forming a pseudo-lateral socket with median cardinal; paired anterior lateral teeth prominent forming a deep socket. lv with 3 cardinal teeth; posterior small laminar, median large, triangular, anterior long, laminar; anterior and median joined dorsally and forming a deep triangular socket; anterior lateral large and in line with anterior cardinal. Ligament small on a deeply sunken nymph below and behind the beaks. Marginal grooves and ridges present: rv with a lunule margin ridge extending well beyond the end of the hinge plate; posterior with a groove extending beyond the mid point. lv as rv but anterior with a groove and posterior with a ridge. Ventral margins smooth. Adductor scars not well defined, equal in size, narrow. Pallial line entire but becoming straight posteriorly instead of forming an indented sinus. Shell colour white, tinged pale orange or pink.

*Anatomy* The gross anatomy is illustrated after removal of the right valve and mantle in Figure 21. The mantle is fused from the posterior adductor to almost the mid point of the ventral margin. There is a simple short exhalant siphon which is surrounded by a minute frill. The inhalant siphon is larger andalso very short, but is surrounded by short simple tentacles. These siphons have little separation and can be regarded as fused. It is probable that these siphons in life do not extend greatly beyond the shell edge.

The ctenidia consist of inner and outer demibranchs with reflected filaments, the outer demibranch is however about one third the size of the inner. The labial palps are very small with few sorting ridges. The foot is blade like with a prominent toe but lacking a demarcated heel.

*Derivation of name* *consternans* from Latin, **dismaying**, referring to the problems encountered with the taxonomy of this species.

*Habitat* Off Muscat, the single living specimen and the many valves were taken from a shell gravel bed at 30 m. In the Bay of Safaga the facies type was predominately muddy sand and occasionally from muddy sand with sea grass from 20 to 30 m. In the Arabian Gulf they were collected offshore in sands at depths of around 20 m.

*Distribution* Known from the Red Sea, Arabian Sea and Arabian Gulf and is probably widely distributed in the Indo-Pacific.

*Remarks* The initial reaction to our observations was that there are two forms, one trigonal the other subovate but the more one tried to make this reaction objective the more obscure the differences appeared. If there are two forms then a morphometric analysis should substantiate this. We measured 10 parameters (Fig. 14) and calculated a number of ratios (Table 1) from these. Looking at the ranges of the ratios it can be seen that there is considerable variation which would lead one to suspect that there is only a single variable taxon present. However some parameters are more instructive than others, especially the ratio of Ht/Hu-a and the anterior apical angle (AUV). Plotting these as a bivariate scattergram (Fig. 22) reveals separation of the Red Sea material into two groups. Statistical analysis of these parameters confirms that they are significantly different at the 99% level with p-values of less than 0.0001. The scattergram does show some outlying individuals but this may be due to error or the extremes of variation. If we include the sample of *M. consternans* from Muscat we see that it agrees entirely with *M. consternans* from the Red Sea but there are no outlying points. This suggests that there may be some errors in assignment of species in the Red Sea where some samples may be partly mixed; no examples of *M. dilecta* were detected in the Muscat sample. We are therefore confident that there are two species present in the Red Sea.

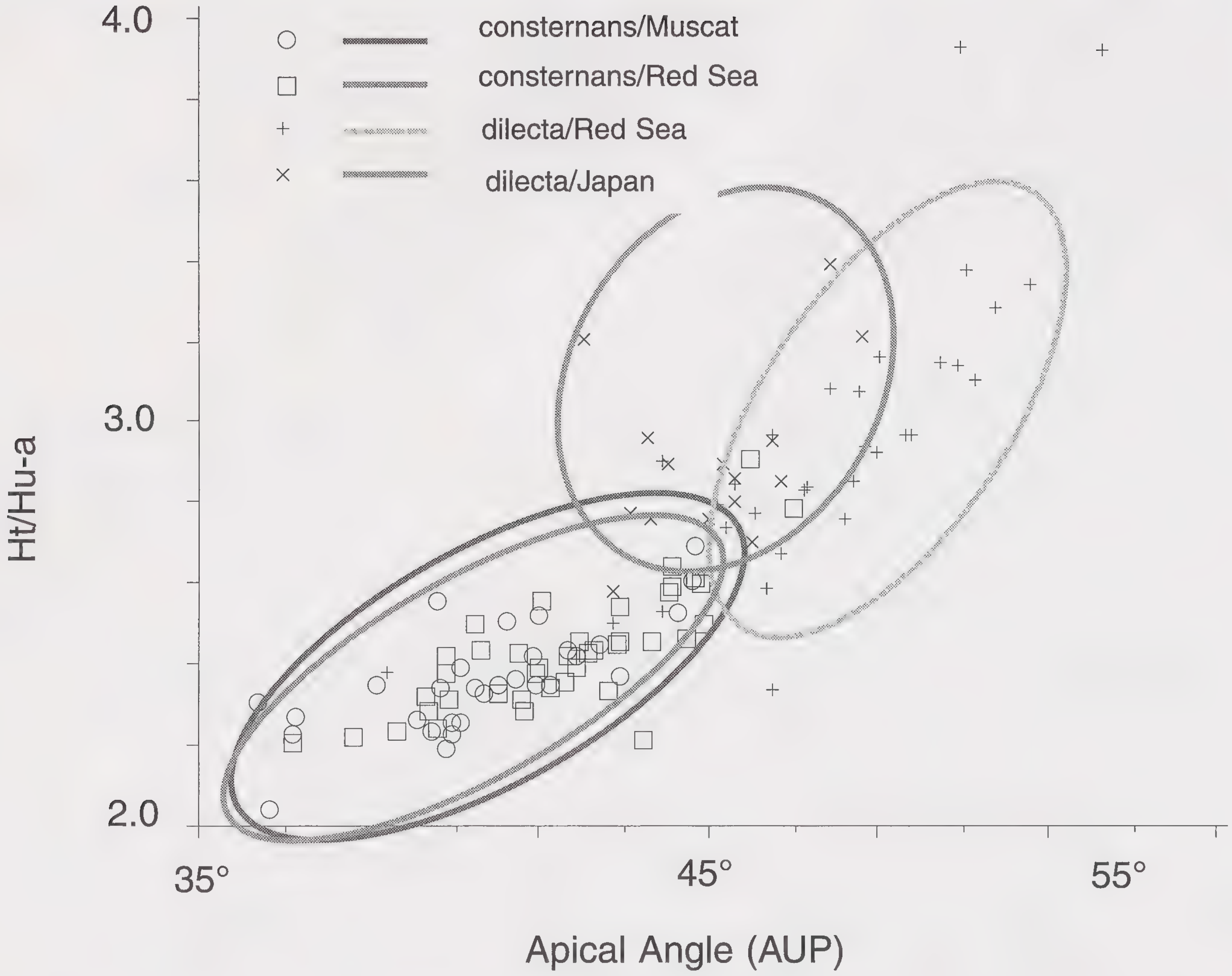


**Fig. 22** Bivariate plots of the Apical Angle (AUP) and the ratio Ht/Hu-a for *Microcirce dilecta* from the Red Sea and Japan and for *M. consternans* from the Red Sea and off Muscat (Arabian Sea).

The shells from the Arabian Gulf and Singapore fall within the range of *M. consternans* rather than with *M. dilecta* (Figs 19–20) but rarely show the extreme triangular end of the range. The Singapore shells show a constant tendancy to have reduced sculpture over the median area but this does not warrant separation at this time and remain included with *M. consternans.*

Moazzo (1939) illustrates a shell (Fig. 23) of some 5 mm in size with a distinctly trigonal outline under the name of *Gouldia minima* var. *triangularis* (Montagu, 1807) from the Gulf of Suez. It bears a striking resemblance to *M. consternans* but is rather large and larger than any specimens seen by us or by Hoenselaar & Dekker (1998). Moazzo's reference is actually to the *Venus triangularis* of Montagu 1803 [p. 577]and is a synonym of *Venus minima* Montagu, 1803 [p. 121], now *Gouldia minima*.

Of all the Circiinae that we could locate only two valid nominal taxa have affinity with the current material namely *Microcirce dilecta* from Japan and *Gouldiopa australis* from south-east Australia. *Gouldiopa* is rather tumid, with distinct deep red beaks and quite unlike *M. dilecta* or *M. consternans*. *Microcirce dilecta* on the other hand is similar and its affinity with the larger Red Sea form needs clarification. Examples from Japan were included in the morphometric analysis and

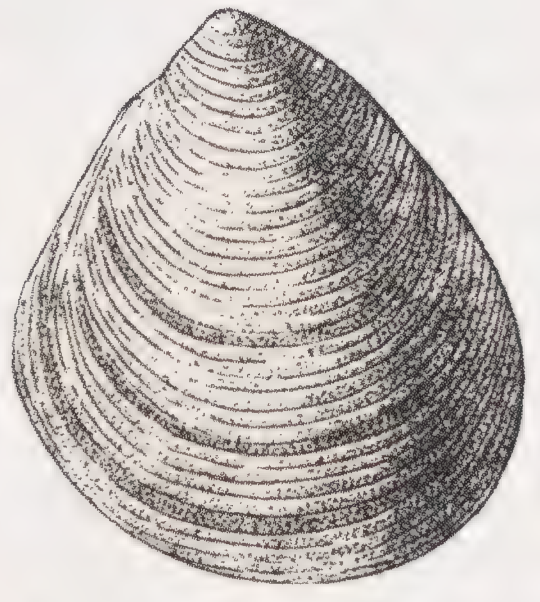


Fig. 4. — *Gouldia minima* MONTG. *var. triangularis?* MONTG. (× 12).

**Fig. 23** *Gouldia minima* var *triangularis* Montagu 1803, from Moazzo, 1939.

although they are distinct from *M. consternans* they overlap considerably with the larger Red Sea form. Although there is some separation we are not prepared to give new nominal status to this Red Sea material and include it within *M. dilecta*.

The ability to examine the anatomy of *M. consternans* allows the superfamily placement to be conclusive. The short fused siphons are typically venerid and unlike the single siphonate condition observed in the Kelliellidae. Clausen (1958) gave a complete account of *Kelliella miliaris* and he noted a single exhalant siphon and that the inhalant aperture was continuous with the pedal gape.

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# SOME NOTES ON *CECILIOIDES ACICULA* (FERUSSACIIDAE) FROM SOUTH IBERIA

*Cecilioides acicula* is a Mediterranean species which has been spread by man to central Europe and western Europe to southernmost Scandinavia (Kerney M.[1]), the eastern United States and Bermuda (Abbott R.T. 1989[2]), the West Indies and South America (Binney W.G. 1885[3]). Very little is known about its behaviour. Ellis (1926[4]) stated that 'it is blind and subterranean, and is said to feed on roots'. Step (1927[5]) wrote that 'it is entirely subterranean in its habits, it is blind, and it is carnivorous, or at least supposed to exist upon animal matter'. Similar reports are in Kerney and Cameron (1979[6]) and Pfleger and Chatfield (1988[7]).

Arrébola Burgos (1995[8]) has found the species in humid places on vegetable or animal matter and between plant roots and in rock crevices, sometimes in clusters. These findings accord with mine and I have found the species in groups of up to ten live individuals under rocks.

I collected two live specimens from Casares in south Spain (N 36°22.956´ W005°13.125´) on 20 November 1999 from a group of about ten individuals under a limestone rock about 80x50x30 cm. The site is low maquis with areas of steppe and grassland and some large *Eucalyptus* sp. trees. The snails were clustered in an area less than 5 cm$^2$ and there were about ten fresh dead shells on the soil (pH 7.0) under the area where the live snails were attached to the rock. I kept the snails in a plastic box 120x80x30 mm with soil and some dry grass stems and roots. The soil is kept moist by periodic addition of water and a few blades of grass are occasionally added. A cover of low growing mould is present on the grass components. The snails are strongly negatively phototaxic and it is difficult to observe them. They are sometimes hidden from view for days at a time and then reappear on the soil surface, seeming to feed on the decomposing grass components and mould. On 27 March 2000 an inspection revealed two adults (the originally collected specimens) and three sub-adults. No stages of breeding were observed. In June 2000 the snails were still alive and a juvenile 1.5 mm long, was seen for the first time. This finding suggests that there are at least two broods in one year. Closer observation, on a regular basis, might shed light on the breeding and other behaviour of these snails. As far as I know, this is the first record of *C. acicula* breeding in captivity.

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# CONCHOLOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

## Report of the Council 1999–2000

The Society announced with regret the deaths of two members, Mr Glen R Webb, member since 1964 and Mr T E Crowley, BSc, MICE, (Honorary) member since 1951, past President, Secretary and Treasurer.

*Council Positions*
Mr Brian Eversham began his final year as President of the Society. New Ordinary Members of Council for 1999/2000 were Dr Honnor, Mr Buckle and Mr Palmer. Dr Rundle, Mr Gillard and Mr Brown began their second year on Council; Dr Aldridge, Mrs Platts and Dr Bishop began their final year on Council. Mr Buckle agreed to serve as Hon. Acting Treasurer, and Mr Wimbleton was co-opted to fill his place as Ordinary Council member. In July Mrs Weideli resigned as Hon. Programme Secretary. All other Council positions remained unchanged.

*Publications*
Two issues of the *Journal of Conchology* (Volume **36**: 5–6) were published. Four issues of the *Conchologists' Newsletter* (Volume **9**, Part 2, Numbers 149–152) were published. Contributions for the *Newsletter* were in short supply during the past year and the Editor would welcome more articles from members. Dr Kerney's *Atlas of the Land and Freshwater Molluscs of Great Britain & Ireland* was published in April 1999 by Harley Books. The Society also published the Annual Programme Card, revised Membership List and mail order form in January 2000.

*Programme of Meetings*
The following events were held in 1999:
**Indoor meetings:** 30 January, *Shells at Hastings, East Sussex: the Collections at Hastings Museum and Present Day Habitats*, speaker Dr June Chatffeld; 13 March (AGM), *Aspects of the Behaviour and Ecology of British Land Slugs*, speaker Mr Brian Eversham; 17 April, *Mollusc Conservation in the National Trust following the November 1996 Cardiff Conference*, speaker Dr Keith Alexander; 18 September, *Antarctic Cephalopods*, speaker Miss Louise Alcock; 23 October, *Welcome to the House of Snails*, speaker Ms Jane Reynolds; 20 November, *Molluscs and Salinity*, speaker Dr Gia Pendred; 11 December, open meeting on the theme of 'my favourite mollusc or mollusc book'. Ms Reynolds replaced the advertised speaker for October Dr Guido Poppe and Dr Pendred replaced Dr Michael Barker in November.
**Field meetings:** 27 February, Barn Elms Wetland Centre, Barnes, London, leader Ms Jane Reynolds; 20th March, Windsor Forest Park, leaders Miss Rosemary Hill and Mr Ron Boyce; 24 April, The Forest of Dean & Wye Valley, leader Mr David Long; 15 May, Cuckmere Valley (N.T.), East Sussex, leader Dr Ed Bishop; 21–23 May, North Lancashire and South Cumbria, leader Dr Barry Colville; 13 June, Winchester Area, Hampshire, leader Dr June Chatfield; 3 July, Market Weston Fen, Suffolk, leaders Mr Ian Killeen and Mr Roy Baker; 24 July, Colchester area, leaders Mr & Mrs Peter & Pam Wilson; 21 August, Herne Bay, North Kent, leader Dr Adrian Rundle; 23–30 September, Scilly Isles, Cornwall, leaders Mrs Jan Light, Mr & Mrs Tom & Celia Pain; 9 October, Wicken Fen,

Cambridgeshire, leaders Dr Richard Preece, Mr Brian Eversham & Mr Adrian Colston. **Workshops:** 14 April, children's holiday events at Haselmere Museum, Surrey, leader Dr June Chatfield, 9 May, Volutes and Olives at Blakes Lock Museum, Reading, Berkshire, leader Dr June Chatfield; 27 November, small British Land Snails and Marine Bivalves at Judith Nelson's home, Woking, Surrey, leader Dr Adrian Rundle.

The above programme was prepared by Mrs Helen Weideli during her term of Office as Hon. Programme Secretary. Council extends its thanks to her for preparing this programme and to all those who took part during 1999, in particular speakers and leaders of field meetings and workshops. I would also like to express my sincere thanks to Mr Ian Killeen, without whose assistance there would be no programme for 2000.

### *Other Council Matters*

Four Council meetings were held and in addition there were two meetings of the Publications Committee and one of the Molluscan Conservation Group of Britain & Ireland. Amongst the issues discussed by Council were recruitment and retention and members, as a result of which it is hoped that a member's guide, to be issued to all members, will be produced. Other issues discussed by Council included the Marine Conservation Society shell curio survey card, the transfer of publications and other material to the Society Archives in Leeds and the forthcoming joint meeting of the Conchological Society and the Malacological Society. On financial matters, Council addressed several issues. It was decided that the Hon. General Secretary would be a signatory on the Society's bank accounts to avoid problems in case of the Treasurer resigning. Council also approved an Expenses Policy Document prepared by Mr Buckle, the Hon. Acting Treasurer. This sets down guidelines for the funds available as expenses for the programme, for officers and other representatives of Council or the Society and to external bodies (i.e. speakers). Council approved the partial funding of the hire of a dredging boat for use on the Isle of Scilly field meeting, but this did not take place due to rough weather. Council also approved a grant of £800 towards the cost of a small boat for research into the spread of the Asiatic clam, *Corbicula fluminea* in East Anglia.

The Conchological Society exhibit moved from the Booth Museum of Natural History in Brighton in June, and was then used at a number of one day events organised by member Mr Hammond of Aspatria, Carlisle. The first showing was to commemorate World Ocean Day, and was at Dumfries. It was also shown at Sandylands on the Solbay Coast, Silloth, Sellafield and Galloway. These were all outdoor events with good attendance by the general public.

I would like to thank all those members of Council who have worked hard over the past year, and to Miss Nelson who has dutifully produced the teas. As this is my last report as Hon. General Secretary I would also like to say how much I regret having to stand down. Many people have given me help, advice and assistance over the past six years, and in particular I wish to thank Mrs Rands, Mr Weideli, Dr Colville, Mr Long, Dr Preece, Mr Killeen and Mrs Light.

Ms J E Reynolds
Hon. General Secretary
March 2000

# TREASURER'S REPORT FOR YEAR 1999

*Income*

Income from subscriptions was £11,013, which is only £17 less than last year. The covenant income anticipated in the Treasurer's Report of 1998 has yet to be realised. Investment income was reduced, in the main by the reduction in interest rates during the year, but also by the redemption of the Whitbread Loan Stock during the year.

*Sales*

Sales of back numbers of the *Journal* and of the *Special Publication* continue to produce a useful source of income. Included in the Sales figure is the sum of £1300 which was realised on the sale of the conchological books bequeathed to the Society by Mr Terry Crowley.

*Donations and Legacies*

We are also grateful to Mr Terry Crowley for his bequest of £500 to the Society, in addition to his conchological books.

*Publications*

The annual costs of publishing and distributing the *Journal of Conchology* and the *Conchologists' Newsletter* remain similar to last year.

*Investments*

The current market value at the end the year was £74,520, an increase of £4,202. The original cost of the same investments was £29,920.

*Fixed Assets*

The computer equipment has been depreciated by £600, as it is the intention to write it off over five years on a straight line basis. A provision was made in the 1998 accounts of £1000 for a replacement computer for the Honorary General Secretary, but as this will not be required in the near future, the provision has been released back into the general funds.

*Movement in Reserves*

The profit for the year of £3655 and the increase in market value of the investments of £4,202, together with the release of the provision of £1000 for a computer, have been added to the Society's reserves.

*Summary*

The Society remains in a sound financial position and it is recommended that the subscription rates remain unchanged. Consideration should be given as to how best to improve services to the members and to further the aims of the Society, as expressed in the constitution.

Pryce Buckle
Hon. Acting Treasurer

# CONCHOLOGICAL SOCIETY OF GREAT BRITAIN & IRELAND. ACCOUNTS FOR THE YEAR ENDED 31 DECEMBER 1999

## INCOME AND EXPENDITURE ACCOUNT

| | **31 Dec. 1999** | 31 Dec. 1998 |
|---|---|---|
| | **£** | £ |
| **Income** | | |
| Fees and Subscriptions | **11,013** | 11,030 |
| Investment Income | **2,843** | 3,902 |
| Sales | **3,009** | 1,248 |
| Donations and Legacies | **520** | 0 |
| | **17,385** | 16,180 |
| **Expenditure** | | |
| Publication Costs | **8,930** | 11,461 |
| Stationery and Sundry Postage | **1,804** | 1,776 |
| Meetings | **890** | 805 |
| Sundry Expenses | **222** | 1,230 |
| Atlases for resale | **1,284** | 0 |
| Depreciation of computer equipment | **600** | 0 |
| | **13,730** | 15,272 |
| **Profit for the year** | **3,655** | 908 |
| **Movement in Reserves** | | |
| Society Reserve Brought Forward | **79,432** | 74,205 |
| Profit for the year | **3,655** | 908 |
| Transfer from Life Membership Fund | **0** | 230 |
| Increase in Market Value of Investments | **4,202** | 4,089 |
| Release of provision for computer | **1,000** | 0 |
| | **88,289** | 79,432 |

## BALANCE SHEET

| | **31 Dec. 1999** | 31 Dec. 1998 |
|---|---|---|
| | **£** | £ |
| **Current Assets** | | |
| Cash at Bank | **19,723** | 14,500 |
| Debtors | **128** | 654 |
| | **19,851** | 15,154 |
| **Current Liabilities** | | |
| Creditors and Accrued Charges | **4,000** | 6,800 |
| Subscriptions in Advance | **1,441** | 564 |
| Life Membership Fund | **2,760** | 2,760 |
| Other Provisions and Reserves | **281** | 1,256 |
| | **8,482** | 11,380 |
| **Net Current Assets** | **11,369** | 3,774 |
| **Investments** - at Market Value | **74,520** | 72,658 |
| **Fixed Assets** - Computer Equipment | **2,400** | 3,000 |
| **Net Assets** | **88,289** | 79,432 |
| **Represented by:** | | |
| Society Reserves | **88,289** | 79,432 |

Pryce Buckle
Hon. Acting Treasurer

N. Light
Hon. Examiner

# REPORT OF THE TRUSTEES FOR 1999

1. The official name of the charity is:
The Conchological Society of Great Britain and Ireland

2. Working names for the charity are:
The Conchological Society or "Conch Soc".

3. The charity's Registered Number is 208205.

4. The official address is:
(Honorary Secretary Ms J Reynolds)
21c Loraine Rd
Holloway
London
N7 6EZ

5. The objects of the Charity's constitution are:
To promote for the benefit of the public the study of Mollusca in its widest aspects.

6. The Trustees' names are:
B Colville and D C Long.

7. The body entitled to appoint trustees is:
Council of the Conchological Society of Great Britain and Ireland.

8. Brief review of the main activities and achievements of the society in relation to its objects:
The Society promoted knowledge of Mollusca through indoor meetings with lectures (7 in 1999), workshops (3 in 1999), and field recording meetings (12 in 1999) either in furtherance of its marine and non-marine mollusc distribution recording schemes for Britain, Ireland and surrounding seas or, in one case, to study fossil molluscs. In 1999 the Society published a quarterly *Newsletter,* 2 parts of the *Journal of Conchology.* A new non-marine mollusc distribution atlas for the British Isles and Ireland was published in April by Harley Books with the Hon. Non-Marine Recorder as author. The data was largely provided by past and present members of the Conchological Society and processed by the Institute of Terrestrial Ecology. The Hon. Conservation Officer has again co-ordinated the provision of molluscan conservation advice to organisations and individuals and has provided molluscan conservation-related news items to the *British Wildlife* magazine.

9. Signature of the trustee authorised to sign the report:

(B Colville) Date: 22.2.00

## 1999 Tax and Dividends from Conchological Society Investments

| | Tax £ | Net Dividend £ | Tax £ | Net Dividend £ |
|---|---|---|---|---|
| M&G Dividend Fund 50280 Units | | (2.1.1999) | | (1.7.1999) |
| (£27100)[1] | 86.48 | 345.93 | 47.32 | 425.87 |
| | 67.38 | 269.50 | | |
| | | (foreign) | | |
| Save and Prosper Smaller Companies | 4.58 | (annual | | |
| Income Fund 7040.4 Units | | dividend | | |
| (£9145) | | 31.3.1999) | | |
| | | 18.31 | | |
| Whitbread 71/4% Loan Stock 1999 | 10.32 | (25.2.1999) | | |
| (£2340) | | 41.27 | | |
| (Matured 25.2. 1999) | | | | |
| Mersey Docks & Harbour Board Co OS | 5.33 | (29.4.1999) | | (29.10.1999) |
| 436 OS | | 47.96 | 2.66 | 23.98 |
| (£1918) | | | | |
| Treasury Stock 2006 73/4% £8270 | | (8.3.1999) | None | (8.9.1999) |
| (£8932) | 64.09 | 256.37 | | 320.46 |
| Royal Bank of Scotland Group plc 1700 | | (19.2.1999) | | (16.7.1999) |
| Ordinary Shares | 74.25 | 296.99 | 15.49 | 139.40 |
| (£17884) | | | | |
| National Savings Income Bond monthly | | | | |
| (£10000) | | | | |

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[1] Except for the Whitbread stock which matured, figures in round brackets are valuations as at 14 January 2000.

## RECORDER'S REPORT: NON-MARINE MOLLUSCA

The *Atlas of the Land and Freshwater Molluscs of Britain and Ireland* (Harley Books, Colchester) was published in June 1999. As was the case with our provisional atlas in 1976 - and indeed has been the experience of other organisers of mapping schemes who have produced atlases - a good deal of fresh information has been sent in following its appearance. No doubt part of the reason has been the simple pleasure of filling in obvious blanks. Much information has also come from the many ecological studies currently underway on rare species. Such work is excellent and desirable. However we should perhaps not lose sight of me fact that many still widespread native species are also declining - the result of changes affecting these islands as a whole as intensive agriculture, urban growth and pollution reduce diversity in the 'ordinary' landscapes that make up by far the greater part of our surroundings. Many habitats once thought commonplace are disappearing, not just those containing rarities which may already have some degree of legal protection. Perhaps we should emulate the ornithologists, who from time to time draw attention to the plight of common birds and the reasons for their decline.

A new field recording card is being designed in collaboration with Dr Mark Telfer of Monks Wood. It will replace our existing card which has done duty since 1978. In the near future it is hoped to computerise all our data on Red Data Book species, and - as a much longer-term project - possibly also the vastly greater amount of site information held in our files.

The following new vice-comital records were all noted and verified during the year ending March 2000:

**Somerset North** (6): *Vertigo pusilla*, Cleeve Wood (31/4666), Janet Boyd.
**Sussex West** (13): *Ferrissia wautieri*, R. Rother, Stopham (51/0318), M.J. Willing.
**Kent East** (15): *Vertigo moulinsiana*, Westbere Marshes (61/2060), I.J. Killeen; *Lehmannia valentiana*, Maidstone (51/7557), R. Carr.
**Surrey** (17): *Paralaoma caputspinulae*, Southwark Park (51/3579; public garden), R. Hawkins (*per* Janice Light).
**Glamorgan** (41): *Hygromia cinctella*, Roath Park, Cardiff (31/1878; garden), M.R. Hughes.
**York South-west** (63): *Lehmannia valentiana*, Tickhill (43/5893; garden), C. du Feu.
**York Mid-west** (64): *Lehmannia valentiana*, Burley Road, Leeds (44/2933), A. Norris.
**Haddington** (82): *Limax maculatus*, North Berwick (36/5485; garden); *Cernuella virgata*, Longniddry Bents (36/4477), both A.T. Sumner.
**Linlithgow** (84): *Planorbis carinatus, Acroloxus lacustris,* Union Canal, Linlithgow (26/9876), A.T. Sumner.
**Fife** (85): *Truncatellina cylindrica*, Dumbarnie Links, Largo Bay (37/4302), G.B. Corbet.
**Forfar** (90): *Pisidium obtusale*, Tarfside (37/4979), T. Huxley.
**Ebudes North** (104): *Boettgerilla pallens*, Eilean Ban, Skye (18/7427), C. du Feu.
**Sutherland West** (108): *Tandonia budapestensis*, Durness (29/4167), A.T. Sumner.
**Outer Hebrides** (110): *Deroceras panormitanum*, Great Bernera, Lewis (19/1438), A.T. Sumner.
**Derry** (H40): *Vertigo geyeri*, Altalacky River, Moneyneany (23/7396), Geraldine Holyoak.

The most important discovery of the past year has been the refinding of *Truncatellina cylindrica* in Scotland, a country where the species has not been seen for many decades. Dr Corbet has shown it to occur (as fresh shells) at several places in stabilised calcareous dunes between Largo and Elie, on the south coast of Fifeshire (*Conchologists' Newsletter* no 152 (2000) p. 281 ). Apart from its occurrence as a fossil in a poorly-dated Postglacial deposit near Elie, the only previous report of the species from Fifeshire dates back as far as 1813, when a specimen was discovered near Balmerino on the north coast of the county by a Mr Chambers, a Kirkcaldy surgeon, and sent to the eminent Scottish zoologist John Fleming, who in 1828 gave a description of it in his *History of British Animals*. Suitable sandy coastal sites would be worth examining elsewhere, especially in Lincolnshire and east Yorkshire where there are Victorian records of *Truncatellina* from sandhills (e.g. near Cleethorpes, or at Kilnsea Warren, near Spurn Head). *T. cylindrica* was rediscovered also in Co. Durham (v.c.66) in the course of a biological survey carried out by the National Trust in 1999 of a dry Magnesian Limestone slope at Horden cliffs (45/4442). The previous Durham find at Claxheugh, near Sunderland, a site probably long since lost through industrialisation, dates from 1840 (verified for the Census from museum specimens in 1934).

Other interesting vertiginid finds of 1999 are of *Vertigo pusilla* from a dry-stone wall in Somerest; *V. moulinsiana* from a *Glyceria maxima* swamp in a drainage ditch in Kent; and *V. geyeri* in a calcareous flush in Co. Londonderry (the first site identified in Northern Ireland).

Among the slugs, *Lehmannia valentiana* (v.c.s 15, 63, 64), *Limax maculatus* (v.c. 82) and *Boettgerilla pallens* (v.c. 104) were all collected from gardens or similar disturbed places and these new discoveries no doubt reflect recent extensions of range. *Tandonia budapestensis* and *Deroceras panormitanum* have now reached the extreme north-west tip of Scotland and the Outer Hebrides respectively. The alien (Mediterranean) helicid *Hygromia cinctella* has turned up for the first time in Wales, in a Cardiff garden (and later it was discovered also in an old quarry at Gorseinon at the other end of the same county, some forty miles further west). Lastly, we have a new locality for the tiny *Paralaoma caputspinulae,* sieved from ground litter in an urban park in South London (v.c. 17). If many native species are declining, their places are being taken by opportunistic introductions which are spreading quickly throughout the British Isles, alas often in habitats where human rubbish may be the most obvious feature.

M.P. Kerney

## MARINE RECORDER'S REPORT 1999

During 1999 computerisation of marine records continued with the enthusiastic support of volunteer members of the Society. Substantial banks of data from the Channel coasts of England and France have been incorporated, in addition to records from other regions falling within the area covered by the Society's Marine Recording Scheme MMNWE, 1990). In particular for the Irish Sea, all the data from the National Museum of Wales' Cruises of 1989, 1991, 1997 and 1998 have been computerised. This represents about 6,000 records from 192 stations, and maps for inclusion in the Cruise Reports can be generated directly from the Society's database. The results from these surveys have provided a detailed insight into the local distribution of the southern Irish Sea malacofauna. In compliance with the Society's protocol on tagging of records according to the requirements of donors of such data, they will not be available for general inspection until the Reports are published.

In September a field trip took place on the Isles of Scilly. Recording, using DOMMIC units as a basis, resulted in records from 26 sites spread over the 5 main islands. Despite the regular and thorough attention the Scillonian marine molluscs have received from amateur collectors and recorders over the past century and half, documented by Turk & Seaward (1997, *Journal of Natural History* **31:** 555–633), the lists from the meeting have resulted in very substantial updating and extensions of range of species' distributions on the islands, including 2 new records. One is *Tonicella rubra* (identity confirmed by Allan Jones) which was found by Peter Topley at Toll's Island. In my report for 1998 I rashly predicted new records for 3 species mentioned in that report. I am happy to say that this proved to be the case for 2 of those species: on 4 of the Isles of Scilly, 6 new sites for *Paludinella littorina* were identified (*J. Conch.* **36**: 85). In Essex, Pam and Peter Wilson have found 2 further sites for *Tenellia adspersa*, one of which is close to the original site at St Osyth Creek and the second is a borrowdyke behind the seawall at Hamford Water some 18 km distant. My third prediction, *Truncatella subcylindrica*, has yet to be found beyond its currently known populations.

*Ensis minor* has hitherto been recorded as having a very restricted distribution in the MMNWE mapping area: live records in that publication being given for S7 Firth of Forth and S53 Rhine (coast of Holland and Belgium). Seaward (1990) noted that the species had not often been distinguished from *Ensis siliqua* although van Urk had indicated that *E. minor* was likely to have a wide distribution along the British coasts. During fieldwork Paul Dansey has found *E. minor* at 2 additional and quite disjunct localities: Cardigan Bay (S22) and Brancaster, Norfolk (S12). These records have been confirmed by Rudo von Cosel.

There is an incentive to logging new records which comes from the 'buzz' of satisfaction of contributing to the pool of distributional data. The more spectacular the species, the greater the enthusiasm, with the consequent danger of throwing caution to the wind. Last year I was notified of the first mainland live record for the ormer, *Haliotis tuberculata*, from Beer Cove near Seaton in Devon. *Haliotis* is known from the French coast and the Channel Islands but has no history of mainland occurrence. The saga is long-winded and will not be dwelt upon here. However, the 'record' was derived from the observations of an amateur marine aquarist who noticed a mystery animal crawling around in his tank. With huge leaps of deduction, he concluded that the ormer had been introduced inadvertently into his tank on a piece of 'limestone' he had collected from the Devon site. After much correspondence (thankfully conducted electronically) it emerged that the aquarist was also stocking his tank with exotic items bought at the local commercial aquarium suppliers. Images of *H. tuberculata* supplied from the Channel Islands were posted on the Web and added to the confusion. Only when a photograph of the actual specimen was disseminated did it emerge (thanks to Daniel Geiger of University of Southern California) that the species was the East African *Haliotis rugosa*. The story had persisted over several months and inevitably the Press printed the story, in south west England and Sussex publications. The find was also flagged on the Internet as the first mainland record and the story took on a life of its own. However, although the Internet was the instrument of widespread and rapid dispersal of the story, so it was also possible to publish a retraction equally effectively. Printed records cannot be erased in this way which is why the Society aims to vet new records rigorously.

Thanks are due to all those who continue to support the Society's marine recording activities.

Jan Light
March 2000

## REPORT OF THE HON. CONSERVATION OFFICER 1999–2000

Selected key items from the 1999–20 year are summarised below.

**Biodiversity Matters**

- Three Council Members attended the annual English Nature 'Species Recovery' conference in February 2000.
- Four Molluscan Conservation Group members are sitting upon UK BAP Steering Groups for a number of the Biodiversity Steering Group's Priority Species. Mollusca include (1 ) the terrestrial species: *Vertigo geyeri, V. genesii, V. angustior, V. moulinsiana* and *Catinella arenaria* and (2) the freshwater species *Pseudanodonta complanata, Pisidium tenuilineatum, Segmentina nitida, Anisus vorticulus* and *Myxas glutinosa.*
- Several Molluscan Conservation Group members have continued to assist Alisa Watson, a PhD student who is working upon a NERC/Environment Agency Research Studentship/Fellowship aimed at determining the key habitat requirements of the Biodiversity Steering Group Priority Species *Segmentina nitida* and *Anisus vorticulus.* Help has included site visits, species identification and research suggestions.
- Molluscan information has been supplied for several local and regional Biodiversity Action Plans including those for West Sussex and Hampshire. County Species Action Plans have been produced for *Helicella itala* and *Mercuria confusa.*
- Several Society members have been involved on a professional basis with survey and monitoring work on Biodiversity Steering Group Priority Species including *Anisus vorticulus, Segmentina nitida, Pisidium tenuilineatum, Vertigo moulinsiana, V. geyeri, V. genesii, Myxas glutinosa, Catinella arenaria* and *Margaritifera margaritifera.* Work has also involved Biodiversity Steering Group Species of Conservation Concern such as *Helicodonta obvoluta, Mercuria confusa, Paludinella littorina, Valvata macrostoma* and *Vertigo lilljeborgi.*

**Advice and help**

Has been given to a wide range of individuals and organisations including:

- Further advice given to the R.S.P.B. ret the management the reserves at Pulborough Brooks (a key area for *Anisus vorticulus* in the Arun Valley).
- Help given to a number of undergraduate and postgraduate students undertaking molluscan based projects and research by identify specimens, providing background information and assisting with report writing.
- Information given to the Environment Agency concerning the management of a number of water courses.
- To English Nature on a wide variety of issues including; the identification of shells collected during surveys; help on the identification and habitat management options for the slug *Tandonia rustica* in Kent; advice on the extension and management of several SSSIs of particular molluscan importance (e.g. hanger woodlands on the South Downs).
- The Lincolnshire Wildlife Trust English Nature/The Environment Agency concerning a development threat to an important *Sphaerium solidum* habitat in Lincolnshire (article appearing in the *Newsletter*).
- The Society has agreed to contribute toward the funding of a boat to allow a Cambridge University team lead by Dr. David Aldridge to undertake urgent research work into the ecology of the introduced bivalve *Corbicula fluminea* in The Broads area.

**British Wildlife**

The production of a biannual molluscan wildlife report for this journal has continued. The appearance of this column has generated numerous molluscan enquiries from individuals and organisations. Additionally the Conservation Officer together with Ian

Killeen, wrote an article on the conservation of *Anisus vorticulus.*

### Joint Committee for the Conservation for British Invertebrates & links with other organisations

Membership of the Committee continues providing valuable contacts with other organisations. The Conservation Officer and President have attended all meetings and the Conservation Officer is a member of the executive of this organisation. The consultative 'Green Paper' exploring the possibility of forming a staffed, national invertebrate co-ordinating organisation is complete and is about to be circulated to invertebrate and other conservation organisations. The JCCBI is involved in two other developments which are pertinent to issues raised in the Green Paper. These involve the creation of two posts both directed specifically toward invertebrate species covered by the UK BAP. One recently advertised post run as a partnership project with Biodiversity Challenge, English Nature and the JCCBI is chiefly concerned with group of BAP beetles; the second forthcoming post will be run by English Nature and the Natural History Museum with JCCBI representation on the Steering Group. This latter post is more wide ranging and is intended to address the need for facilitation of working linkages between UK BAP SAPs (species action plans) and UK HAPs (habitat action plans); local action plans the National Biodiversity Network; invertebrate interest groups like the and the Wildlife Trusts. More details of this post and the possible involvement of the Conchological Society will appear in the *Newsletter*.

### Links with other organisations

The Conservation Officer continues to attend conservation committee meetings of The Sussex Wildlife Trust. He was also able to present a talk to a branch of the Sussex Wildlife Trust on the conservation of local freshwater Mollusca. Two field meetings were held to assess the molluscan importance of National Trust properties in the Cuckmere valley, East Sussex and at Wicken Fen, Cambridgeshire. Both meetings provided valuable data that will assist the Trust in maintaining the molluscan interest of the sites investigated. Further survey meetings on National Trust properties are planned for the 2000 season. The Joint Nature Conservation Committee has asked the Society for help in 2000 with a review of the British Red Data Book entries on non-marine Mollusca.

### Commercial exploitation of foreign shell material

The Society's intention to investigate the trade in exotic shell products was reported last year. As a result we have joined the Marine Conservation Society in undertaking a survey of the marine shell and 'curio' trade in a wide range of commercial outlets throughout the country. A 'Curio Trade Survey' card has been distributed with the *Newsletter*.

### Conservation work undertaken throughout the Society

Many other conservation activities have been undertaken throughout the year by Society members, often in a professional capacity. These are too numerous to mention individually, but range from continued work with the DOMMIC (English Channel) marine molluscan mapping project, molluscan surveys of freshwaters and wetlands throughout the country.

M.J. Willing

## MEMBERSHIP SECRETARY'S REPORT FOR 1999 (AGM MARCH 2000)

Membership of the Society at the end of 1999 was 348. This includes Life Members, Honorary Members, Ordinary Members, Family Members, Student Members and Institutions. There have been 9 new members in the year, but 24 members have resigned or lapsed through non-payment, giving a net loss of 15 members for the year.

During the year there were 89 Subscribers to the *Journal of Conchology*. This compares with 88 in 1998.

Mike Weideli
Hon. Membership Secretary

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Manuscripts should be sent to:

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# Journal of Conchology
Vol. 37, Part 2, January 2001

## Contents

PAGE

### PAPERS

CARLSSON R. Ecology and lifecycle of *Myxas glutinosa* (Müller) in lakes on the Åland Islands, southwestern Finland. 105

SMITH D.G. Observations on the morphology and anatomy of *Margaritinopsis dahurica* (Middendorff, 1850) (Unionoida: Margaritiferidae). 119

HELLER J. & SIVAN N. *Melanopsis* from the mid-Pleistocene site of Gesher Benot Ya'aqov (Gastropoda: Cerithioidea). 127

IBÁÑEZ M., ALONSO M.R. & VALIDO M.J. *Plutonia solemi* new species (Gastropoda: Vitrinidae: Plutoniidae) from La Palma (Canary Islands). 149

SIMONE L.R.L. Revision of the genus *Parabornia* (Bivalvia: Galeommatoidea: Galeommatidae) from the Western Atlantic, with description of a new species from Brazil. 159

MENEZ A. Assessment of land snail sampling efficacy in three Mediterranean habitat types. 171

ALDRIDGE D.C. & MÜLLER S.J. The asiatic clam, *Corbicula fluminea,* in Britain: current status and potential impacts. 177

CAMERON R.A.D. Changes in the land mollusc fauna of the South Haven Peninsula, Dorset, between the 1930s and 1999. 185

GERLACH J. On a new species of *Nesokaliella* and further comments on the affinities of the genus (Gastropoda: Limacoidea). 205

OLIVER P.G. & ZUSCHIN M. Minute Veneridae and Kelliellidae from the Red and Arabian Seas with a redescription of *Kellia miliacea* Issel, 1869. 213

### COMMUNICATIONS

MENEZ A. Some notes on *Cecilioides acicula* (Ferussaciidae) from south Iberica. 231

PROCEEDINGS 233

QL
401
.Q15
MOLL

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# ON THE UNNECESSARY RENAMING OF HOMONYMS IN PYRAMIDELLIDAE

G. ROSENBERG[1] & R.E. PETIT[2]

*Abstract* *Two recent articles, by Pimenta and Absalão (1998) and Corgan and Aartsen (1998), were published for the sole purpose of replacing names of homonyms in the Pyramidellidae. Both articles ignored provisions of the International Code of Zoological Nomenclature. Corgan and Aartsen failed to demonstrate that the secondary homonyms that they replaced were congeneric with their supposed senior homonyms. Both sets of authors failed to demonstrate that the names they replaced referred to valid species. Among the replacement names by Pimenta and Absalão,* Turbonilla nesiotes *is a nomen dubium and* Turbonilla sinensis *is preoccupied by Clessin, 1900; among those by Corgan and Aarsten,* Turbonilla sulcatella *is a nomen dubium and* Turbonilla abnormalis *is unnecessary as secondary homonymy did not exist between* Chemnitzia ambigua *Saurin, 1962, a* Turbonilla, *and* Turbonilla ambigua *Deshayes, 1861, a* Syrnola. *Renaming of homonyms outside the context of systematic revisions leads to needless proliferation of names and should be avoided.*

*Key words* Turbonilla, *Pyramidellidae, homonymy, unnecessary replacement names*

## INTRODUCTION

We were disturbed to see papers published recently in *Journal of Conchology* and *Basteria* that introduced ill-advised and unnecessary new names for molluscan species. These papers, by Pimenta and Absalão (1998) and Corgan and Aartsen (1998) were apparently written under the misconception that any junior homonym encountered must be replaced. Such an idea might be fostered by a quick reading of the first part of Article 60 of International Code of Zoological Nomenclature (ICZN). In the following, we quote from the third edition of the ICZN, which was in force when the names in question were introduced, adding the number of the corresponding article in the fourth edition in brackets. The text of the fourth edition does not differ substantially. In the quotations, bracketed items are in the original text, but we have added the italics. Article 60(a) [60.1] states:

"A junior homonym [Art. 52] *must* be rejected and replaced either by an existing available name or, for lack of such a name, by a new replacement name (nomen novum), unless the junior homonym is rejected as a junior synonym...."

"While this applies to all primary homonyms, it does not apply to all secondary homonyms, as stated in Article 59(c) [59.2]:"

"If, in a case of secondary homonymy, the junior species-group name has not been replaced [Art. 60], and the taxa in question are no longer considered congeneric, the junior name is not to be rejected, even if one name was originally proposed in the current genus of the other."

To define terms we quote Article 53(c) [53.3]:

Two or more available species-group names having the same spelling are homonyms if they were originally established in combination with the same generic name (primary homonymy), or if they were subsequently published in combination with the same generic name (secondary homonymy)....

---

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[2] 806 St Charles Road, North Myrtle Beach, South Carolina 29582, USA.

### Pimenta and Absalão, 1998

In the authors' efforts to identify specimens of *Turbonilla* from the Brazilian coast, they uncovered four preoccupied names which they replaced with new names. All of the nomina involved were originally proposed in *Turbonilla* so only primary homonymy is involved. None of the renamed nominal species occur in Brazil, yet the authors failed to state where they do occur. This means that future workers may easily overlook these new names, since indexing sources such as the Zoological Record will not be able to attribute them to the correct fauna. Furthermore, the authors did not attempt to trace the type material of any of the taxa, and have not demonstrated that any of the taxa has been considered valid since they were first named. In short, no need for these new names has been demonstrated.

#### *Turbonilla nesiotes* Pimenta & Absalão, 1998
Figures 1A–B

This name was proposed to replace *Turbonilla abrupta* Clessin, 1900 [cited as 1902 by Pimenta & Absalão], non Bush, 1899. We have not found any record of this nominal species, described from Cuba, being recognized in later literature. It was not listed by Espinosa, Fernández-Garcés and Rolán (1995) in their catalog of the Recent marine molluscs of Cuba. The original illustration and description are not sufficient to identify the species.

The holotype of *Turbonilla abrupta* Clessin (Zoological Museum of Berlin [ZMB] 54686) is a pale brown, incomplete specimen, dimensions 3.24 x 1.00 mm. The original description in Latin says "2" whorls, but in German says "?"; "2" is probably a mistranscription of "?". The original illustration (Clessin 1900, pl. 29, fig. 6) shows 5 whorls, which matches the number now remaining in the holotype (Fig. 1A–B). The complete shell probably would have been longer than 6 mm and had more than 10 whorls. The specimen is no longer shiny (it was described as "nitida"), and the spiral sculpture has been obliterated (perhaps by Byne's disease) except for traces on the body whorl, where 15 evenly spaced spiral grooves are visible in the intercostal spaces and sides of the ribs behind the aperture. The fifth groove below the suture is slightly wider. The body whorl bears 23 completely straight, slightly prosocline axial ribs, which are about as wide as their interspaces and which do not continue onto the base. The base shows traces of 4 or 5 spiral cords. The columella has a single fold. The remaining teleoconch is straight-sided, with slight dorsoventral curvature along the shell axis. The sutures are shallow and whorls slightly convex to flat.

Among named species of Western Atlantic *Turbonilla*, this description is most similar to that of *T. obeliscus* C. B. Adams, 1850, however, that species is white rather than the brownish yellow that Clessin described for *T. abrupta.* In the absence of knowledge of the protoconch, apical whorls and basal sculpture of *T. abrupta* it and its replacement name, *T. nesiotes,* must be considered nomina dubia, until their status is clarified by a systematic revision of the genus.

#### *Turbonilla sinense* Pimenta & Absalão, 1998: 63
Figure 1C

This name was proposed as a replacement name for *Turbonilla stricta* Clessin, 1900 [cited as 1902 by Pimenta & Absalão], non *T. stricta* Verrill, 1873. This new name is stillborn, being preoccupied by *Turbonilla sinensis* Sowerby, 1894 which was listed and figured by Clessin (1900:152). Pimenta & Absalão incorrectly used the neuter form *sinense,* rather than *sinensis,* in combination with the feminine *Turbonilla*

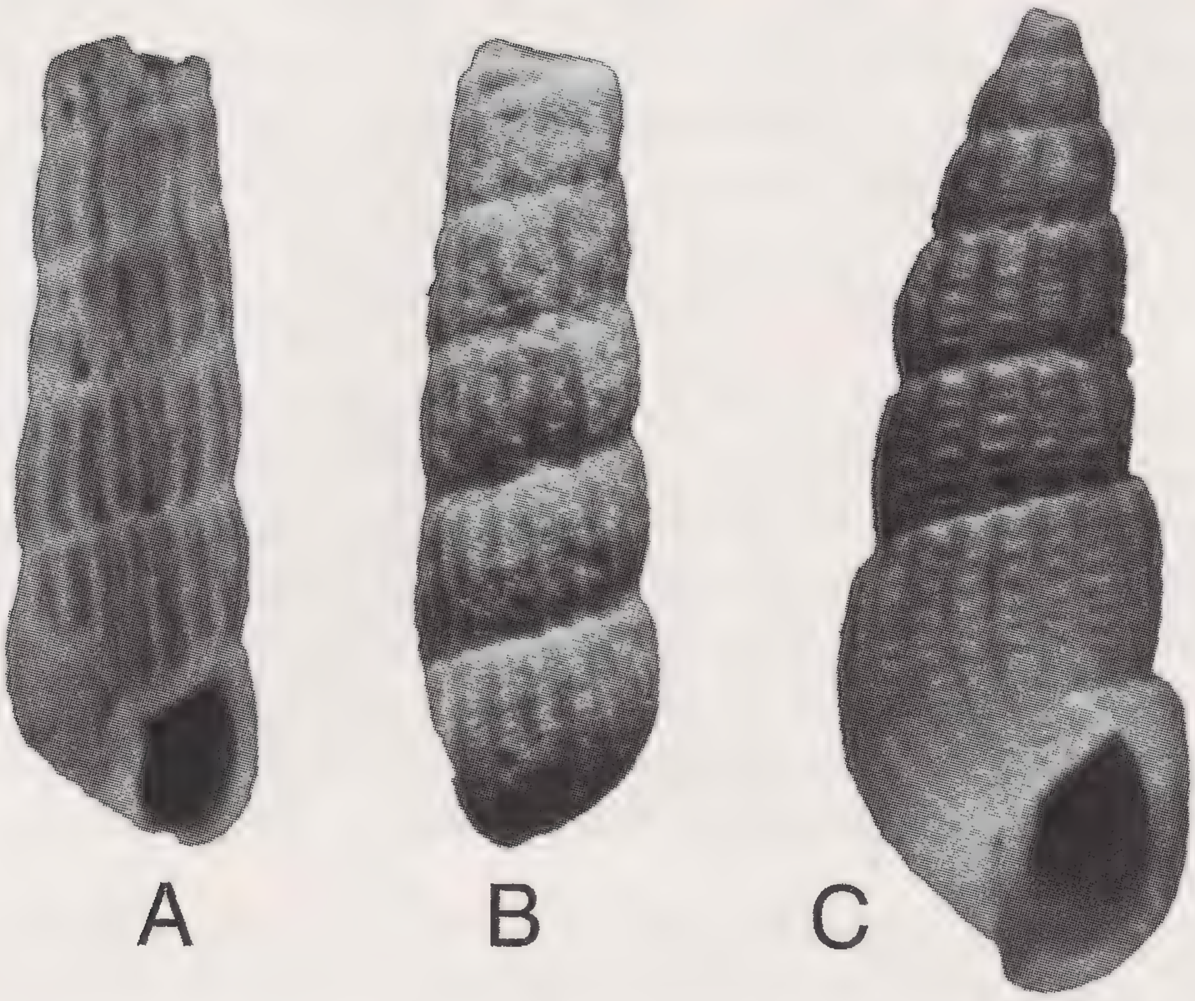

**Figure 1** **A–B** *Turbonilla abrupta* Clessin, 1900. Holotype ZMB 54686, height 3.24 mm. **C** *Turbonilla stricta* Clessin, 1900. Syntype ZMB 54690, height 4.0 mm.

Clessin's taxon was described from Makao (= Macao). The original illustration and description are not sufficient to identify the species. Examination of four syntypes of Clessin (ZMB 54690) shows that the Clessin's illustration is highly inaccurate, and that the species is not a *Turbonilla,* but possibly a *Pyrgulina.* One of the syntypes is illustrated here (Fig. 1C).

### *Turbonilla vix* Pimenta & Absalão, 1998

This name was proposed to replace *Turbonilla hemphilli* Bartsch, 1917, non Bush, 1899. Neither the spatial or temporal provenance of Bartsch's taxon is given; it was described from the Pliocene of San Diego, California. In their major work on California Pliocene Mollusca, Grant & Gale (1931) merely listed the original description and gave no additional records. In their short discussion of the Pyramidellidae they stated that "many supposed species should be regarded as synonyms " (1931: 865). Dr. James H. McLean (Los Angeles County Museum of Natural History) stated "*Turbonilla hemphilli* is the third of five names for one broadly ranging species, according to my tentative synonymies for the NE Pacific pyrams" (email to GR, 29 January 1999).

### *Turbonilla zulmae* Pimenta & Absalão, 1998: 63

This name was proposed to replace *Turbonilla elongata* Castellanos, 1982, non Pease, 1868 [cited as "1967" and "1867" by Pimenta & Absalão]. There is no indication that Dr. Castellanos was afforded the opportunity to provide a replacement name herself, as suggested by the Code of Ethics (ICZN Appendix A.3). She described the species from off southern Buenos Aires Province, Argentina.

## CORGAN AND VAN AARTSEN, 1998

The purpose of the paper by Corgan and Aartsen was to provide replacement names for six pyramidellid molluscs described by Saurin in 1958, 1959, and 1962, the names of which they considered to be preoccupied. The authors gave no indication that any of these names have been used since their introduction, nor did they mention searching for any possible synonyms as available replacement names, even among the 255 names stated to have been proposed by Saurin. They called these preoccupied names "meaningful", but gave no evidence that they should be recognized as valid species. No statement was made as to the current location of Saurin's type specimens.

### *Turbonilla inclinella* Corgan & Aartsen, 1998

This is a replacement name for *Chemnitzia obliqua* Saurin, 1959, stated to be preoccupied by *Turbonilla obliqua* Degrange-Touzin, 1894, and by *Chemnitzia obliqua* Laseron, 1959. Corgan and Aartsen did not state the present generic placement of *Turbonilla obliqua* Degrange-Touzin, but our examination of the original description and figure (pl. 9, figs. 4–4a) shows that the species fits the current concept of *Turbonilla,* thus secondary homonymy does exist. It may even be referable to the subgenus *Chemnitzia,* as it lacks spiral sculpture and has axial ribs terminating at the periphery. Corgan and Aartsen give no evidence, however, that *Chemnitzia obliqua* Saurin is a good species in need of a replacement name.

The authors also had difficulty establishing the relative priority of the publications of Saurin and Laseron and stated that in the absence of contact with the University of Saigon Press they "assume that Saurin's work appeared at the end of 1959, the nominal year of publication." However, they overlooked the date "2-10-59" (2 October 1959) printed on the journal's back cover. Laseron's work is dated as "October, 1959", and must, in the absence of other evidence, be dated as October 31, 1959, under Article 21(c)(i) [21.3.1], which makes it junior to Saurin's work. As the nomina of Saurin and Laseron are primary homonyms, Laseron's taxon will have to be renamed if study of Australian Pyramidellidae shows it to be a good species without a synonym to serve as a replacement name.

### *Turbonilla normalis* Corgan & Aartsen, 1998

This is a replacement name for *Chemnitzia ambigua* Saurin, 1962, supposedly preoccupied by *Turbonilla ambigua* Deshayes, 1861. The authors did not state that *Turbonilla ambigua* Deshayes is still placed in the genus *Turbonilla.* Examination of Deshayes' figure (pl. 21, fig. 20) shows that his species is certainly not a *Turbonilla* as it is entirely smooth. Cossmann (1921: 231) placed the species in *Syrnola (Pachysyrnola)* and we agree that it is a *Syrnola.* Schander, Aartsen and Corgan (1999) classified *Syrnola* in Syrnolidae, so it is not even confamilial with *Turbonilla.* Therefore the names were not secondary homonyms and the replacement name is unnecessary.

Corgan and Aartsen (1998) implied that other secondary homonyms might exist, stating that a "general review of possible homonyms ... lies beyond the scope of this study." As they made no mention of any search for possible synonyms, the scope of their study was not wide enough to prove the necessity of the replacement names they introduced. We note for completeness that Corgan and Aartsen dated this Saurin publication as 1961, which is the date on its front cover, but the back cover gives the date "4-6-62" (June 4, 1962).

### *Turbonilla (Jordaniella) sulcatella* Corgan & Aartsen, 1998

This is a replacement name for *Odostomia (Jordanula) infrasulcata* Saurin, 1959, preoccupied by *Odontostomia (Syrnola) infrasulcata* Tate, 1898. The authors considered these names to be "objective homonyms." It is not known what they meant by "objective homonyms" as homonyms are either junior or senior to one another, and they are either primary or secondary. This may reflect a misunderstanding of Article 57e [57.5]:

"In combination with the same generic name, identical species-group names established for different nominal taxa are homonyms even though the spelling of the generic name with which one or both have been combined is an emendation [Art. 33b] or an incorrect spelling, whether original [Art. 32c] or subsequent [Art. 33c]; such names are deemed to have been combined with the generic name in its correct form..."

By this article, these names are primary homonyms, because *Odontostomia* is an (unjustified) emendation of *Odostomia.* Even in such a case of primary homonymy, a new replacement name is not needed unless the species is valid and no existing synonym is available to serve as a replacement name. Saurin's figured specimen of *Odostomia infrasulcata* (pl. 3, fig. 26) might easily be a worn specimen of *Odostomia zaleuca* Melvill, 1911, shown on the same plate (fig. 24). Saurin's description of the embryonic whorls being entirely immersed might instead be interpreted as a septal plug having been mistaken for a missing protoconch. In the absence of a type specimen or other material demonstrating the nature of the protoconch, it is impossible to judge the status of this species, and *Odostomia infrasulcata* and *Turbonilla sulcatella* are thus nomina dubia.

## DISCUSSION

Of the ten homonymous names replaced by Pimenta & Absalão (1998) and Corgan & van Aarsten (1998), we have shown that five are currently invalid, two being nomina dubia (*T. nesiotes* P. & A. and *T. sulcatella* C. & A.), one being itself preoccupied (*Turbonilla sinensis* P. & A.), one because secondary homonymy did not exist *(Turbonilla normalis* C. & A.), and one because prior replacement names exist (*Turbonilla vix* P. & A.). Most of the remaining five names will likely also prove unnecessary, as research on pyramidellids shows that older names exist for these species, or that the replacement was unnecessary under ICZN Article 59(d) [59.4], which states:

"A species-group name rejected after 1960 on grounds of secondary homonymy is to be reinstated by anyone who believes that the two species-group taxa in question are not congeneric, unless it is invalid for some other reason."

Saurin (1959) and Laseron (1959) used a much narrower concept of the genus *Turbonilla* than did Corgan and Aartsen, and recognized *Turbonilla* and *Chemnitzia* as two separate genera. Many authors currently treat *Chemnitzia* as a subgenus of *Turbonilla,* rather than a synonym. As anatomical knowledge of pyramidellids increases, it is likely that some subgenera of *Turbonilla* will be elevated to full genera, and that new genera will be named. For this reason, it is inadvisable to rename homonyms outside the context of systematic revisions that determine the validity of species and their current generic placement.

Scanning almost any page in Ruhoff (1980) will uncover homonyms, yet her work covers only a twenty year span. Other homonyms are easily found by other simple searches. The renaming of homonyms when it is not known if synonyms are available for replacement names, and when it is not known whether type material exists, places undue hardship on future workers doing either monographic work on the groups in question, or faunal studies of the areas from which the nomina are supposed to have been found. The existence of homonyms in itself is no reason for proposing new replacement names. In any event, all replacement names should be published in accordance with the ICZN, and care taken to ensure that additional homonyms and synonyms are not created.

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# INTRODUCED LAND MOLLUSCS ON THE ISLANDS OF THE TRISTAN DA CUNHA - GOUGH GROUP (SOUTH ATLANTIC)

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*Abstract Three introduced species of land snail (*Oxychilus alliarius, Vitrea contracta *and* Lauria cylindracea*) and five species of slug* (Deroceras reticulatum, D. laeve, D. panormitanum, Milax gagates, Lehmannia valentiana) *are reported from islands in the Tristan da Cunha - Gough group. All eight species were found on Tristan da Cunha itself, the largest island and the one most severely affected by human disturbance. A few, notably* Oxychilus alliarius, Deroceras reticulatum, D. laeve *and* D. panormitanum, *have also been found on some of the other islands, where they have spread into various communities of native vegetation. On Inaccessible Island,* O. alliarius *occurred in some peculiar habitats, including dried holdfasts at the top of the boulder beach. These introduced species have western Palaearctic origins but are likely to have reached the Tristan - Gough islands with supplies imported via South Africa.*

*Key words Tristan da Cunha, Inaccessible Island, Gough Island, introduced land molluscs*

## INTRODUCTION

Tristan da Cunha is one of the most remote inhabited islands in the world. It is the largest of four islands that form the Tristan - Gough group situated in the middle of the South Atlantic, about 2800 km from South Africa and 3200 km from the nearest point of South America. Three islands, Tristan, Inaccessible and Nightingale, lie close together near 37°S 12°W and form the northern group, whereas Gough Island (40°S 10°W) lies about 350 km to the SSE. The islands are volcanic in origin but they differ markedly in age and erosional state.

Dispersal to such remote oceanic islands obviously presents severe difficulties to those organisms lacking any ability to fly. Indeed, only two genera of land snail are native to the islands of the Tristan - Gough group. *Tristania* was originally believed to be endemic but has recently been shown to be congeneric with the Palaearctic clausiliid genus *Balea* (R.C. Preece & E. Gittenberger, in prep.). It is represented by six very different forms, which have been accorded the status of species (Odhner, 1960), a problem discussed elsewhere (R.C. Preece & E. Gittenberger, in prep.). *Succinea,* the only other native genus of land snail, occurs on Gough (Quick, 1957), Inaccessible (R.C. Preece, unpublished) and possibly Tristan (Holdgate, 1965). These two genera share attributes, such as the ability to secrete extremely sticky mucous and to produce young in the absence of mates, that would favour successful colonization following passive dispersal by birds (cf. Cockerell, 1921; Falla, 1960).

The occurrence of introduced species on remote oceanic islands, such as those of the Tristan - Gough group, is also of interest since it provides a crude measure of the degree of disturbance suffered by each island. In such ecologically sensitive places, it is also important to assess the potential threat that these alien species pose to indigenous taxa and to evaluate any other ecological consequences that might ensue. This paper provides some new information on the occurrence of introduced land molluscs on Tristan and Inaccessible, resulting primarily from fieldwork undertaken during the Denstone Expedition in 1982 (Swales *et al.*, 1985). The specimens have been deposited in the University Museum of Zoology, Cambridge. No information exists for Nightingale Island. Information from Gough, designated a World Heritage Site by UNESCO in 1995, is also reviewed.

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## THE ISLANDS AND THEIR INTRODUCED LAND MOLLUSCS

### TRISTAN DA CUNHA

Tristan is the largest (86 km$^2$) and youngest island with the least degraded topography. It is also the highest with a summit reaching 2060 m above sea-level. Potassium-argon ages demonstrate that the accessible lavas of the main shield-building phase were erupted about 0.2 and 0.1 Ma ago (Gass, 1967; McDougall & Ollier, 1982). Volcanic activity has continued intermittently until the present day, as exemplified by the eruption of October 1961, when all the islanders had to be evacuated. Apart from a two year period following this event, Tristan has supported a human population continuously since 1816, when a British garrison was established following Napoleon's exile to St Helena, 2400 km to the north-east. The village on Tristan, known as The Settlement, is located on a coastal plain in the north of the island and now has about 300 inhabitants.

Tristan supports five native vegetation types, which are clearly zoned according to altitude and topography (Wace & Holdgate, 1958; Wace & Dickson, 1965). Little information exists about the molluscs from the fern-bush, wet heath, bog and feldmark communities, since most of the collecting has been undertaken in the vicinity of The Settlement. This area would originally have had a thick cover of tall tussock grass *(Spartina arundinacea)* but all extensive areas of tussock and most of the fern-bush on the lower ground have now been cleared to make pasturage for cattle (Wace & Holdgate, 1976). Moreover, almost every island tree *(Phylica arborea)* in the vicinity of The Settlement has been removed for fuel. The area around The Settlement now consists of grassland or stony pasture dominated by alien plants.

Various synanthropic habitats were sampled for molluscs in this general area. Three species of land snail and five species of slug were discovered (Table 1). *Oxychilus alliarius,* the only land snail previously recorded from Tristan, was common in various gardens in The Settlement, as well as in The Potato Patches, about 2.5 km to the west, where the islanders grow most of their vegetables. Together with several other introduced invertebrates, it has also successfully invaded areas of native vegetation, occurring abundantly in unmodified fern-bush on the slopes leading up to The Base, between 600 and 900 m above sea level, where the gradients leading to the summit slacken. None

TABLE 1
Occurrence of introduced land molluscs on the islands of the Tristan - Gough group

| | TRISTAN | | | | INACCESSIBLE | | | | | GOUGH | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gardens/Potato Patches | Walls | Grassland areas near Settlement | Fern-bush | Holdfasts at top of boulder beach | Coastal vegetation | Under dead bark of *Phylica arborea* | Fern-bush | Wet heath | Coastal vegetation | Fern-bush | Wet heath (<400 m) | Peat bog/Wet |
| *Lauria cylindracea* (da Costa) | - | + | - | - | - | - | - | - | - | - | - | - | - |
| *Vitrea contracta* (Westerlund) | - | - | + | - | - | - | - | - | - | - | - | - | - |
| *Oxychilus alliarius* (Miller) | + | - | + | + | + | + | + | + | + | + | + | + | + |
| *Milax gagates* (Draparnaud) | + | - | + | - | - | - | - | - | - | - | - | - | - |
| *Lehmannia valentiana* (Férussac) | + | - | - | - | - | - | - | - | - | + | + | - | - |
| *Deroceras laeve* (Müller) | - | - | + | - | - | + | - | + | + | - | - | - | - |
| *Deroceras panormitanum* (Lessona & Pollonera) | + | - | - | - | - | - | - | - | + | - | - | - | - |
| *Deroceras reticulatum* (Müller) | + | - | + | - | - | + | - | + | + | + | + | + | + |

of these specimens smelled strongly of garlic, despite vigorous irritation to the animal. *Lauria cylindracea* was found on stones used to make some of the garden walls in the Settlement. In all specimens examined the angular lamella was connected to the outer lip of the mouth by thick callus, a feature characteristic of *L. cylindracea cylindracea.* Specimens from other Atlantic islands (i.e. Macaronesia) showing no such connection have sometimes been regarded as a separate sub-species *(L. cylindracea anconostoma)* but there is often considerable variation. *Vitrea contracta* occurred under stones on the grassland between the eastern limit of the Settlement and the area of new lava resulting from the 1961 eruption. Two species of slug, *Deroceras reticulatum* and *Milax gagates,* were previously known from Tristan (Holdgate, 1965) and these were found to be widespread in the vicinity of The Settlement and The Potato Patches. Associated with these in several gardens were *D. panormitanum* (= *Agriolimax caruanae)* and *Lehmannia valentiana,* which were found amongst rotting vegetation. *Deroceras laeve* occurred in damper areas under stones and wood in this general area.

## INACCESSIBLE ISLAND

Inaccessible (12 km$^2$), an uninhabited island located 40 km SW of Tristan, is the remnant of a much larger volcanic edifice that appears to have built up during the last 3 Ma (Chevallier *et al.*, 1992). The island derives its name from the precipitous nature of the cliffs that bound much of its coastline and from the fact that landing on the west coast near Blenden Hall, where the gradient is gentler, is often impossible because of heavy swell. It is consequently seldom visited, although cattle, sheep, goats and pigs have all been introduced at one time or another (Wace & Holdgate, 1976) but none remain today.

Tussock grassland *(Spartina arundinacea)* forms extensive stands on much of the low-lying terrain and dominates the steep coastal cliffs up to 500 m. In areas of tall dense growth, vascular plants are excluded. Fern-bush, dominated either by dwarf tree-ferns *(Blechnum palmiforme)* in the west or island tree *(Phylica arborea)* in the east, covers much of the plateau. A narrow area of wet heath occurs along the western edge of the plateau and some small valley bogs, dominated by *Sphagnum,* are also present on the eastern part. Roux *et al.* (1992) provide a detailed account of the vegetation on Inaccessible, from which they record 94 species of vascular plants, 31 of which are endemic and 26 introduced. Alien plants were less common on the plateau than at lowland sites, where they were frequent in areas of disturbance, such as landslips and man-modified sites (Dean *et al.*, 1994).

*Oxychilus alliarius* was the only introduced species of land snail discovered (Table 1). It occurred in a range of different habitats and was particularly common under stones and amongst moss at various lowland sites around Blenden Hall. It even occurred, together with *Tristania tristensis,* amongst dried holdfasts at the top of the boulder beach, where it would certainly have received a regular drizzle of salt spray. Some of the specimens from this habitat were quite sizeable (up to 7.9 mm in breadth). On the plateau it was found in *Blechnum palmiforme* heath, together with *Tristania* spp. and was also present under the bark of dead *Phylica* trees, where it occurred with woodlice, worms and amphipod crustaceans. *O. alliarius* also occurred, together with *Tristania* and *Succinea,* in the area of wet heath along the western margin of the plateau. Three species of slug, *Deroceras reticulatum, D. laeve* and *D. panormitanum,* were also present in this area of wet heath. *D. reticulatum* and *D. laeve* also occurred in open areas bordering the stream in Ringeye Valley, as well as marshy places in the coastal area around Blenden Hall.

## GOUGH ISLAND

Gough is the southernmost and second largest island (57 km$^2$) and is the most complex in terrain and structure. It is also the wettest, coldest and most rugged of all the islands in the Tristan - Gough group. It is not as old as previously thought, the oldest exposed lavas now being dated at 2.55 Ma (Maund *et al.*, 1988). A weather station (with 6-8 personnel) has been maintained on Gough since 1955 and this is provisioned annually with supplies from South Africa.

Gough supports five vegetation types, all largely undisturbed and uncontaminated by alien species. Some 36 species of flowering plant and 27 pteridophyte taxa are native to Gough but only 17 alien species of vascular plant are known (Groves, 1981). The coastal cliffs and penguin rookeries are mantled by tussock grasses (both *Spartina arundinacea* and *Parodiochloa flabellata).* The more sheltered lower ground up to about 300 m is covered by fern-bush, where dense thickets of *Phylica arborea* grow amongst dwarf tree-ferns. Above this is a zone of wet heath with creeping plants, tufted grasses, sedges and moss mats, extending up to 600 m. Above this again, and extending up to the highest peaks at about 900 m, is a feldmark montane vegetation with a sparse plant cover and thin wind-eroding peats (Wace, 1961; Wace & Holdgate, 1976).

*Oxychilus alliarius* is the only introduced species of land snail known from Gough, where it was widespread before the establishment of the weather station (Holdgate, 1965). As on the other islands it was common in litter, moss and soil in the tussock grassland forming much of the coastal vegetation and was also frequent in fern-bush (Table 1). On Gough it had a mainly lowland distribution, only rarely being encountered in wet heath above 400 m, although it has been found at 680m in wet heath bordering a pool at Sea Hen Crag (A. Jones, pers comm.). It is widely distributed on Gough, occurring in The Glen, in the uplands of Gonydale and even on Penguin Island, a small islet off the east coast (M.W. Holdgate, unpublished data).

In the mid 1950s slugs were not found in natural habitats on Gough but two slugs were collected by Martin Holdgate on cabbage seedlings imported from Tristan. These specimens cannot be traced and their specific identity is uncertain (cf. Holdgate, 1965). On a return visit to Gough in 1968, Holdgate collected several specimens of *Deroceras reticulatum* amongst litter near the old base in The Glen. These specimens are in the Natural History Museum, London. In 2000, the Gough Island Terrestrial Invertebrate Survey (GITIS) found that *D. reticulatum* had spread away from the lowlands near the base and now occurs in various native vegetation communities, including those on the slopes of Edinburgh Peak (910m), the highest point. Specimens of *Lehmannia valentiana* were also found at two lowland sites, at Snoek Gat and in fern-bush south-west of The Admiral.

## DISCUSSION AND CONCLUSIONS

The occurrence of these alien species on the islands of the Tristan - Gough group has obviously been mediated by human agency and it is interesting to speculate about their origins. The number of outside visitors to the islands was far greater when whaling was at its height, but from around 1870 the frequency of vessels visiting Tristan began to decline sharply (Wace & Holdgate, 1976). Today external contact is minimal and often confined to infrequent visits by occasional yachtsmen and the annual visit of the supply ship from South Africa. Contact between the islands is scarcely any more regular. For over a century the residents of Tristan have made regular boat jouneys between the three northern islands, carrying stores, plants and sometimes stock. Since 1948 annual (or more frequent) voyages have been made by fishing ships between Tristan and Gough and this inter-island traffic is likely to have facilitated the spread of species throughout the group (Holdgate, 1965).

The islands differ markedly in the extent to which they have been disturbed by human activities. Tristan, which has supported the largest human population for the longest time, is the worst affected. Of the 195 species of vascular plant recorded from Tristan, some 115 are introduced (Groves, 1981). The total number of species of alien invertebrates on Tristan also nearly outnumbers the native fauna (Holdgate, 1965). Most of these introductions are restricted to The Settlement, or to cultivated ground and imported plants. This applies to the three species of land snail and five species of slug now known from Tristan, although *O. alliarius* has spread into areas of native vegetation, as it has on both Inaccessible and Gough. Three of the five species of slug known from Tristan have also been found on Inaccessible, both at coastal sites and on the plateau, and two species have reached Gough, where one *(D. reticulatum)* appears to have spread extensively during the last 30 years.

Most of the alien plants on the Tristan - Gough group seem to have originated in the Palaearctic region and to have arrived on the islands via Cape Province of South Africa (Groves, 1981: 414). Their numbers appear to have increased markedly during the period in which grazing animals, such as cattle, sheep and goats, were introduced (Groves, 1981). The eight species of introduced land mollusc likewise have Palaearctic, or more specifically western Palaearctic, affinities, although several are also known from other Atlantic islands (Wollaston, 1878). Indeed all eight are known from the Azores (Backhuys, 1975) and Madeira (Waldén, 1983; M.B. Seddon, pers. comm.), six occur in the Faroes (Fog, 1971; McMillan, 1972) and four have each been found on the Cape Verde islands (Groh, 1983) and St Helena (Crowley & Pain, 1977; Crowley, 1978). It is possible that the alien land molluscs on islands of the Tristan - Gough group were inadvertently introduced by European settlers or by visiting whalers and sealers during the 19th century. This may well be the case for the most widely distributed species, such as *Oxychilus alliarius*. However, apart from *Vitrea contracta,* which might nevertheless be included in aggregate records of *Vitrea crystallina,* all the introduced species found on Tristan also occur as aliens in South Africa (van Bruggen, 1964; 1991). Since almost all of the supplies now reach the islands of the Tristan - Gough group via South Africa, it seems more likely that the alien taxa have been secondarily introduced from there in more recent times. Additional support for this idea is the fact that *D. panormitanum* (= *D. caruanae*) has even been found in the vicinity of the base station on the subantarctic island of Marion (47°S 38°E), that also receives supplies almost exclusively via South Africa (Smith, 1992). The base station was only established in 1949 and the slug was not recorded during the first thorough biological survey of the island in 1965–6 (Smith, 1992).

The eight species of introduced land molluscs on Tristan form part of a large group of so-called 'travelling species' that are frequently dispersed into new habitats wholly or in part as the result of human activity (Robinson, 1999). Various pathways have been identified, including accidental introduction with imported horticultural plants and vegetables, the most likely routes in the present case. Indeed the interception of the slugs on Gough on cabbage seedlings imported from Tristan provides empirical evidence for this means of introduction. Several of the introduced taxa found on Tristan have even spread to the New World where, in the case of *L. valentiana* (an Iberian species), they may have been present since the Spanish colonization (Waldén, 1961). Other New World introductions from Europe appear to have been more recent (Hanna, 1966; Roth & Pearce, 1984).

The slugs on Tristan have already become pests, eating vegetables and other plants as they do elsewhere. However, neither they, nor the other introduced land snails, are likely to pose a serious threat to any of the native communities of plants or animals. This is not to say that their occurrence will have no ecological consequences. Many subantarctic islands support impoverished biotas, lacking the usual range of herbivores, so that most of the energy and nutrients must pass through a detritus, rather than a grazing chain. Decomposition processes therefore become especially important but these are retarded by adverse climatic effects on microbial activity. Slugs act as both herbivores and detritivores and so may be of considerable significance for energy and nutrient transfers. On Marion, for example, two slugs added to decomposing plant litter enhanced nitrogen mineralization fourteen-fold and phosphorus mineralization tenfold, over rates found in the absence of slugs (Smith & Steenkamp, 1990). It remains to be seen whether the introduced land molluscs play a similar role on the islands of the Tristan - Gough group.

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# THE DECLINE AND PROBABLE EXTINCTION OF *GRAECOANATOLICA MACEDONICA* (GASTROPODA: ORIENTALLNIDAE) IN BALKAN LAKE DOJRAN

SANDRA RYAN[1] & HUW I. GRIFFITHS[2]

*Abstract* Graecoanatolica macedonica *Radoman & Stanković, 1978 is a small orientallnid snail endemic to Balkan Lake Dojran. A recent limnological survey, coupled with repeated searches of the species' type locality and neighbouring sites have failed to recover live specimens of the species. As Lake Dojran has been heavily impacted by water abstraction, it is assumed that* G. macedonica *is now extinct as the shallow littoral area it formerly inhabited is now fully terrestrial.*

*Key words* Graecoanatolica, *Gastropoda, extinction, lakes, Dojran.*

## INTRODUCTION

Genus *Graecoanatolica* (Hydroboidea; Orientallnidae) presently consists of eight species, all confined to either the southern Balkans or Anatolia (Radoman, 1985). *Graecoanatolica macedonica* was described by Radoman & Stanković (1978) from shells taken from Kaldrma on the western shore of Lake Dojran on the Macedonian/Greek border, with subsequent details of the soft-parts being described by Radoman (1983). The general shell morphology of *G. macedonica* (see fig. 1) is typical of the genus in both size and shape (Radoman, 1983; Radoman & Stanković, 1978).

*Graecoanatolica macedonica* is endemic to Lake Dojran (fig. 2) and, like *Graecoanatolica vegorriticola* (Schütt, 1962) from Greek Lake Vegorritis, is presumed to have evolved in situ from the "ponding out" of the vast Plio-Pleistocene palaeolakes of the region (see Grubić, 1980; Radoman, 1985). The Dojran Basin, within which L. Dojran lies, is itself a relict of the vast palaeolake Lake Peonic (Cvijić, 1911) - three times larger and ten times deeper than Dojran's present area and depth (Stanković, 1931). However, in the last three decades there has been increasing loss of the lake's waters through abstraction (Andrejević, 1988; Gasevski, 1991) with accompanying lake-level decline and shoreline recession, and the disruption of ecological communities (Griffiths, Reed, Leng, Ryan & Petkovski, submitted).

### STUDY SITE

Lake Dojran has an area of ca 40 km$^2$, lies between 41°10′ - 41°15′ N and 22°12′ - 22°47′ E at 146–148 m asl, and straddles the borders of Macedonia and Greece (ca 66% of its area being within the territory of the former). Maximum water depth was 10.4 m in the 1930s (Stanković, 1931), but in 1995 was reported have fallen to 5.6 m (Stojanovski & Krstić, 1995). The lake sits within a karstified basin ("polje") formed by a combination of Tertiary volcanic and tectonic activity (Stojanov & Mičevski, 1989). The Dojran Basin's sediments are largely composed of mineral-rich ancient alluvial and limnic sediments (Vilarov, 1956) and, because of the lake's shallowness and the karstification of much of the underlying substratum, L. Dojran is calcite- and chloride-rich, alkaline, eutrophic and highly productive (Stanković, 1931; Petrović, 1968; Griffiths *et al.*, submitted). Local summers are hot and dry, winters are mild and damp, and evaporative losses from the lake are great, volume being maintained by submerged springs in the deeper part of the lake, and by seasonal springs that carry snow-melt from nearby Mt. Belasica and Mt.

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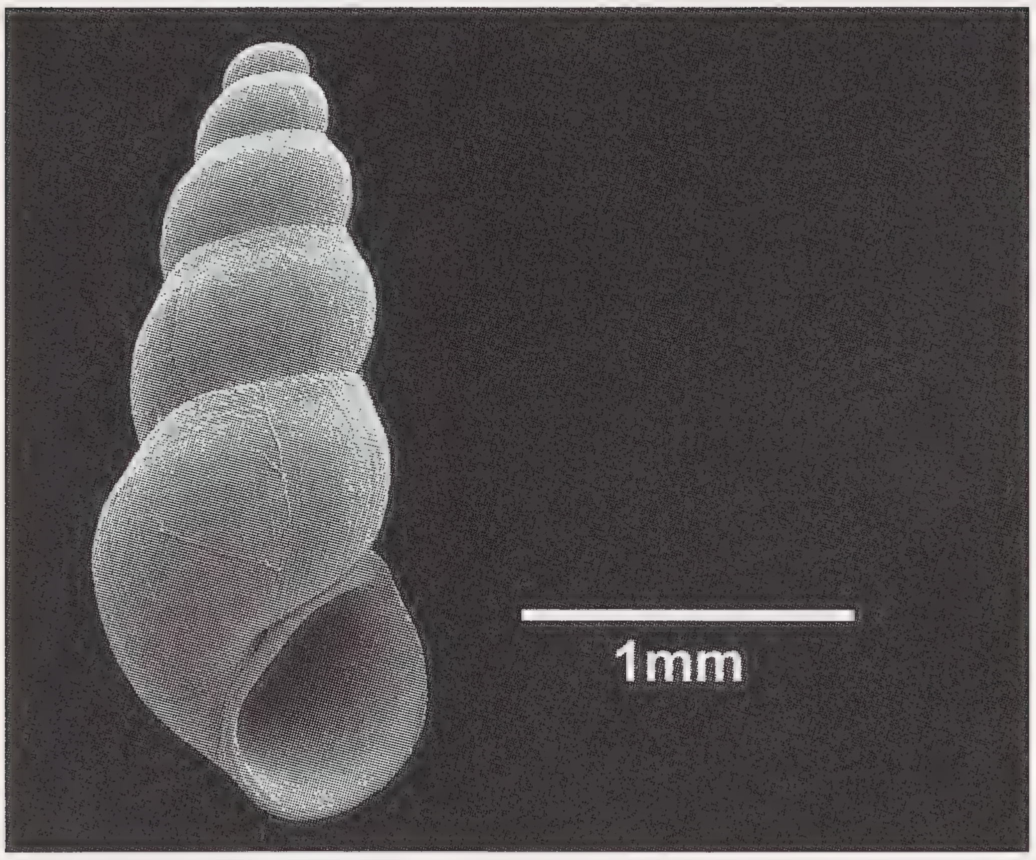

**Fig. 1** *Graecoanatolica macedonica* Radoman & Stanković, 1978. Topotypic material from Kaldrma (col. 17.viii.1989; leg. S. Stanković).

Karadag (Stanković, 1931).

Several authors have discussed the molluscan community at L. Dojran. Following the nomenclature of Turner, Kuiper, Thew, Bernansconi, Rüetschi, Wüthrich & Gosteli (1998), the species recorded from the lake thus far are: *Oxyloma pfeifferi, O. elegans, Lymnaea palustris, Radix auricularia, R. peregra, R. ovata, Galba truncatula, Physa fontinalis, Physella acuta, Planobarius corneus, Planorbis planorbis, Acroloxus lacustris, Valvata piscinalis, Bithynia leachi, G. macedonica, Amphimelania holandri, Anodonta cygnea, Dreissena polymorpha, Unio pictorum* and *Pisidium* spp. (see Roding, 1966; Šapkarev, 1969, 1975; Šapkarev & Angelovski, 1978, 1981; Šapkarev & Stojanovski, 1967; Štanković, 1985; Štanković-Jovanović, 1989).

## METHODS

Lake Dojran was surveyed in September 1997 and 1998 using qualitative spot collections at *G. macedonica*'s type locality at Kaldrma, during which suitable microhabitats were searched and bulk vegetation and substrate samples taken. In addition, to examine whether *G. macedonica* occurs in other shallow parts of the lake basin, thirty quantitative samples were taken from the Macedonian part of the lake (1998 only). Grab samples were collected from a motor boat with a Van Veen Grab, and sampling-site positions were recorded by hand-held GPS (Garmin GPS75). Samples were sieved on site to 120 µm and conserved in 100% ethanol until examined in the laboratory under a zoom dissecting microscope (Zeiss, UK). Twenty of the thirty grab samples collected were selected for further elaboration.

## RESULTS

The contents of the L. Dojran samples comprised eight major taxonomic groups: Crustacea, Insecta, Oligochaeta, Nematoda, Hirundinea, Acari, Mollusca and Hydrozoa, however, the last four groups were poorly represented. Ostracod crustaceans were the most abundant group numerically (comprising almost 50% of the zoobenthos) and attained extrapolated densities of 2,070 inds.m$^{-2}$ (mean = 868 inds.m$^{-2}$), of which 47.6% were the cosmopolitan species *Darwinula stevensoni* (see Griffiths & Butlin, 1994). No live specimens of *G. macedonica* were found, either in the lake itself or during searches at the type locality (Kaldrma) and adjacent areas.

## DISCUSSION

The distribution and ecology of *G. macedonica* have been described in some detail (e.g.

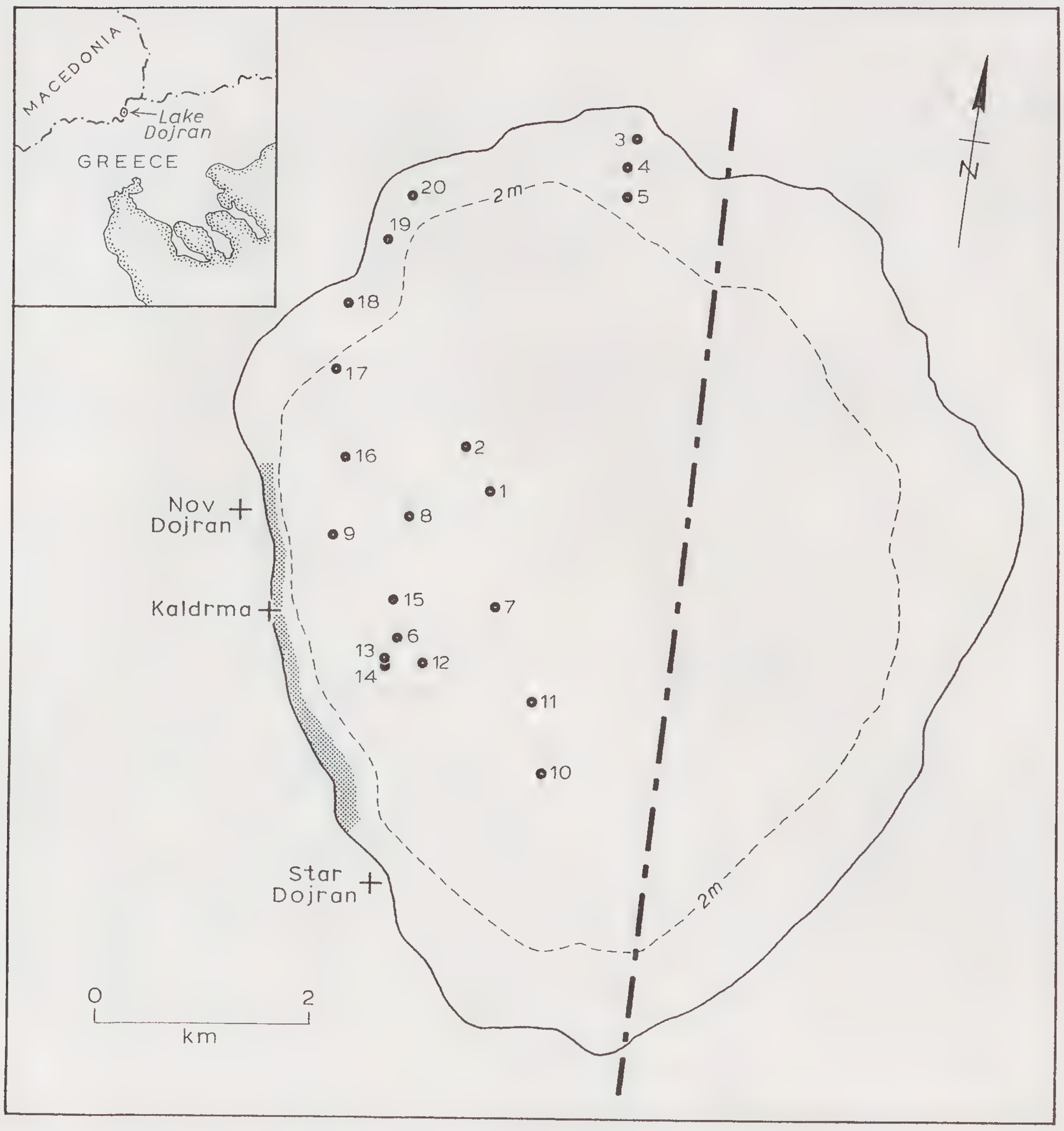

**Fig. 2** Lake Dojran. Closed circles show Van Veen sampling stations The stippled area shows the known area of former distribution of *G. macedonica*. Broken line = former 2m isobath (source: Šapkarev, 1975). The actual date of this line is unknown although it was prior to the extinction). The 2m isobath has since retreated further into the lake but its present position is unclear due to the restriction of modern maps of the area.

Šapkarev, 1975; Stanković, 1985, 1987, 1985; Stanković-Jovanović, 1989). (The taxon listed as "*Bythinelopsis dojranensis* Had." by Šapkarev (1975) is a synonym nomen nuden of *G. macedonica*; S. Stanković, pers. comm.). *Graecoanatolica macedonica* is known from the type locality of Kaldrma and (less abundantly) in the vicinity of Star Dojran (Stanković-Jovanović, 1989), where it sometimes formerly attained extrapolated densities of 25,000 inds.m$^{-2}$ (Stanković, 1987). Its distribution was restricted to sandy and stony substrates in the lake's littoral zone, usually at depths of 0–*c*. 50 cms (Šapkarev, 1975; Stanković, 1987; Stanković-Jovanović, 1989). Thus, an extensive series of samples taken between the early 1970s and early 1980s showed the species to occur in a comparatively restricted area along the lake's western shoreline (see fig. 2).

Population decreases were reported in the mid-1970s as a response to lowered lake levels (see Stanković, 1987; Griffiths *et al.*, submitted). Since then, the status of L. Dojran has changed considerably - one outflow event alone (in 1988) having led to the loss of 20,000,000 m$^3$ of lake water and a further lake level decrease of 60 cms. This, combined with continued interference with feeder sources and hot, dry summers have led to shoreline recession and extensive damage to the littoral zone, particularly along the lake's western shore (Blaženčić, & Blaženčić, 1997; Georgievska & Matevska, 1996; Griffiths *et al.*, submitted).

Reduced densities, coupled with the species' status as a single-site endemic indicate that *G. macedonica* should have been considered as a category CR (Critically Endangered) species under the IUCN's Mace-Lande criteria (IUCN, 1994). However, even though L. Dojran is protected by Macedonian "national monument" (as are nearby

Lake Ohrid and L. Prespa) (Shnajder Jakobi, Anastovski & Gorgievski, 1997), the protection of the site is geopolitically problematic. This is largely due to the lack of overall political co-operation between Greece and Macedonia, and the continued use of waters from the lake's feeder streams and underlying aquifer for agricultural purposes by both nations. The results of the lack of a co-ordinated lake management plan are that the lake's level is continuing to fall, whilst urban pollution leads to increasing trophic status (Griffiths *et al.*, submitted).

Repeated visits to L. Dojran have revealed no live specimens of *G. macedonica* since 1992, and the almost complete loss of the shallow littoral habitats known to be inhabited by the species have led to suggestions that *G. macedonica* may be extinct (Stanković, 1996). The results of the present survey seem to confirm this.

## ACKNOWLEDGMENTS

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# THE DISTRIBUTION AND TAXONOMY OF *VERTIGO MOULINSIANA* (DUPUY, 1849) IN ITALY (GASTROPODA: PULMONATA: VERTIGINIDAE)

G. Manganelli[1], S. Cianfanelli[2], M. Brezzi[1] & L. Favilli[1]

*Abstract* Vertigo moulinsiana *(Dupuy, 1849) has been recorded from 19 sites in ten regions of Italy, but only six of these records could be checked: five were correct and one was based on a misidentification. In the last 30 years, recent specimens have been found in ten sites in only six regions of Italy (Piedmont, Emilia Romagna, Tuscany, Campania, Calabria and Sardinia). Despite its wide distribution, the species seems very rare and extremely localized. This makes it difficult to propose a conservation strategy.*

*Italian specimens of* V. moulinsiana *vary widely in shell shape and in the structure of the apertural armature; their size range is broader than that previously recorded for the species. Some of the smallest Italian specimens fall in the size range of* Vertigo lilljeborgi *Westerlund, 1871, but their assignment to this species would not be realistic because they are the smallest specimens from populations with the same size range as that of* V. moulinsiana.

*Key words* Vertigo moulinsiana, *Italy, taxonomy, distribution, status and conservation*

## Introduction

The European - Maghrebian *Vertigo moulinsiana* (Dupuy, 1849) is regarded as a threatened species throughout its distribution (Collins & Wells, 1987; Wells & Chatfield, 1992; Bailie & Groombridge, 1996) and has been included in the Annex II of the Habitats and Species Directive (92/43/EEC). It is also regarded as a "Mediterranean element" (Butot & Neuteboom, 1958) or "southern species" (Waldén, 1986) of the European fauna due to the fact that its distribution was wider during the warm early Postglacial period (Butot & Neuteboom, 1958; Waldén, 1986; Wells & Chatfield, 1992). The present contracted distribution is presumably due to cooler temperatures and recently also to habitat destruction (Kerney, 1991; Drake, 1999).

Despite its alleged "Mediterranean" or "southern" character, its southern distribution is imprecisely known. In Spain the species is recorded only from near Barcelona and along the Ebro and small rivers in Catalonia (Haas, 1929; Boettger, 1936; Bech, 1990), as a Holocene fossil from sediments exposed in the Rio Heneras Valley in central-northern Spain (Preece, 1991) and perhaps also from the "alluvions du Xénil à Grenade" in Andalusia as *Vertigo graellsiana* Servain, 1880 (Seddon & Holyoak, 1993). In western North Africa, Seddon & Holyoak (1993) made the first record from Morocco and stated that the Algerian *Vertigo codia* Bourguignat, 1864, from "alluvions de l'Oued-Mazafran et de l'Harrach, près d'Alger" may be a junior synonym of *V. moulinsiana*.

Records of *V. moulinsiana* from Italy are few and scattered. Although these reports have never been carefully checked, subsequent authors have cited some of them, overlooked others and reported new findings (e.g. Ehrmann, 1933; Boettger, 1936; Butot & Neuteboom, 1958; Alzona, 1971; Bishop, 1976, 1980; Collins & Wells, 1987; Wells & Chatfield, 1992; see Appendix 1).

New data from central Italy prompted this note, which summarizes the current knowledge of the distribution, status and conservation of *V. moulinsiana* in Italy.

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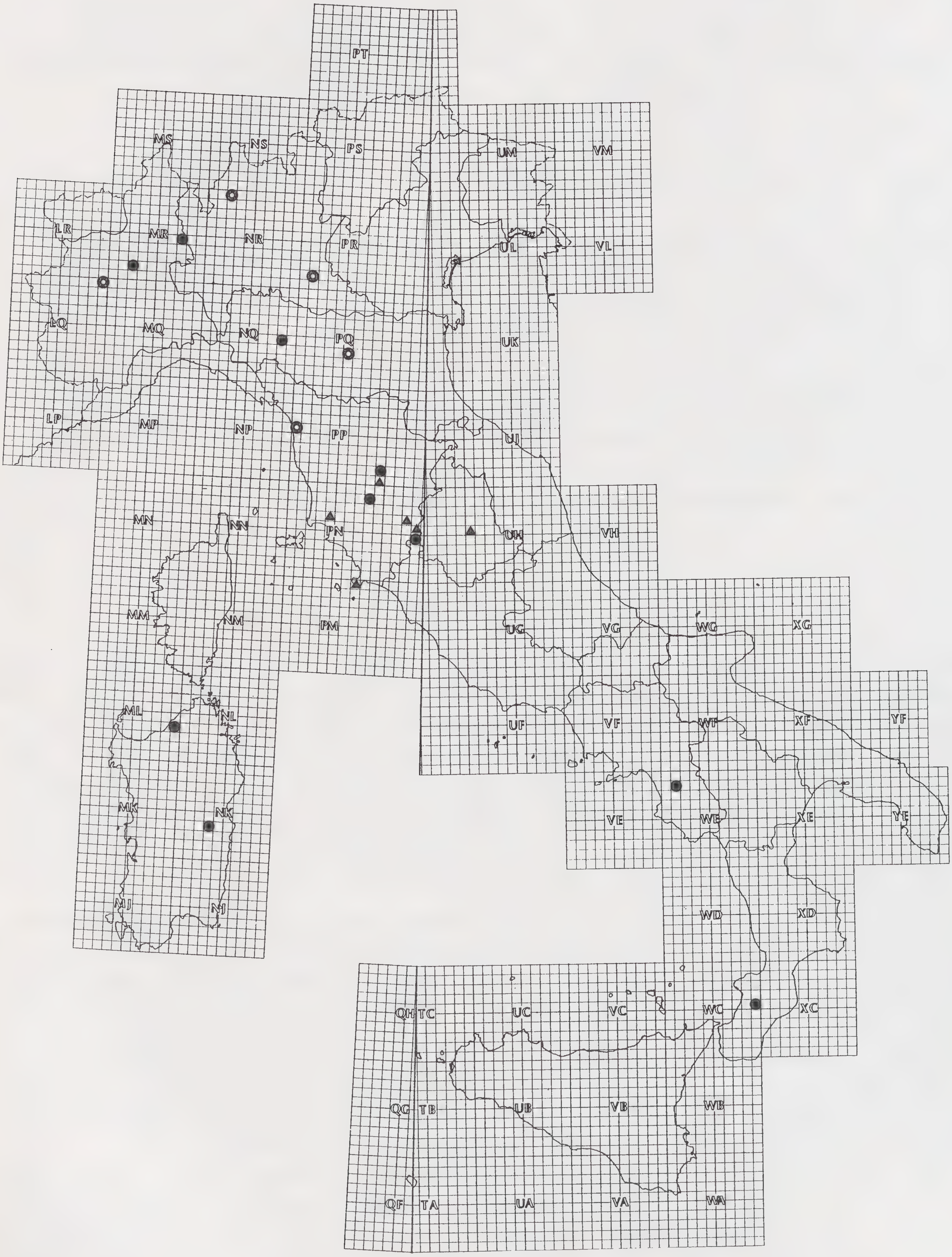


**Fig. 1** The distribution of *Vertigo moulinsiana* (Dupuy, 1849) in Italy. Dots indicate recent historical (open circles) or unpublished (circles) records, triangles possibly Holocene records. Some recent records are based on findings in debris which may be from near or distant sites. Twelve historical reports, which it has not been possible to check, have been omitted.

## DISTRIBUTION AND STATUS OF *VERTIGO MOULINSIANA* IN ITALY

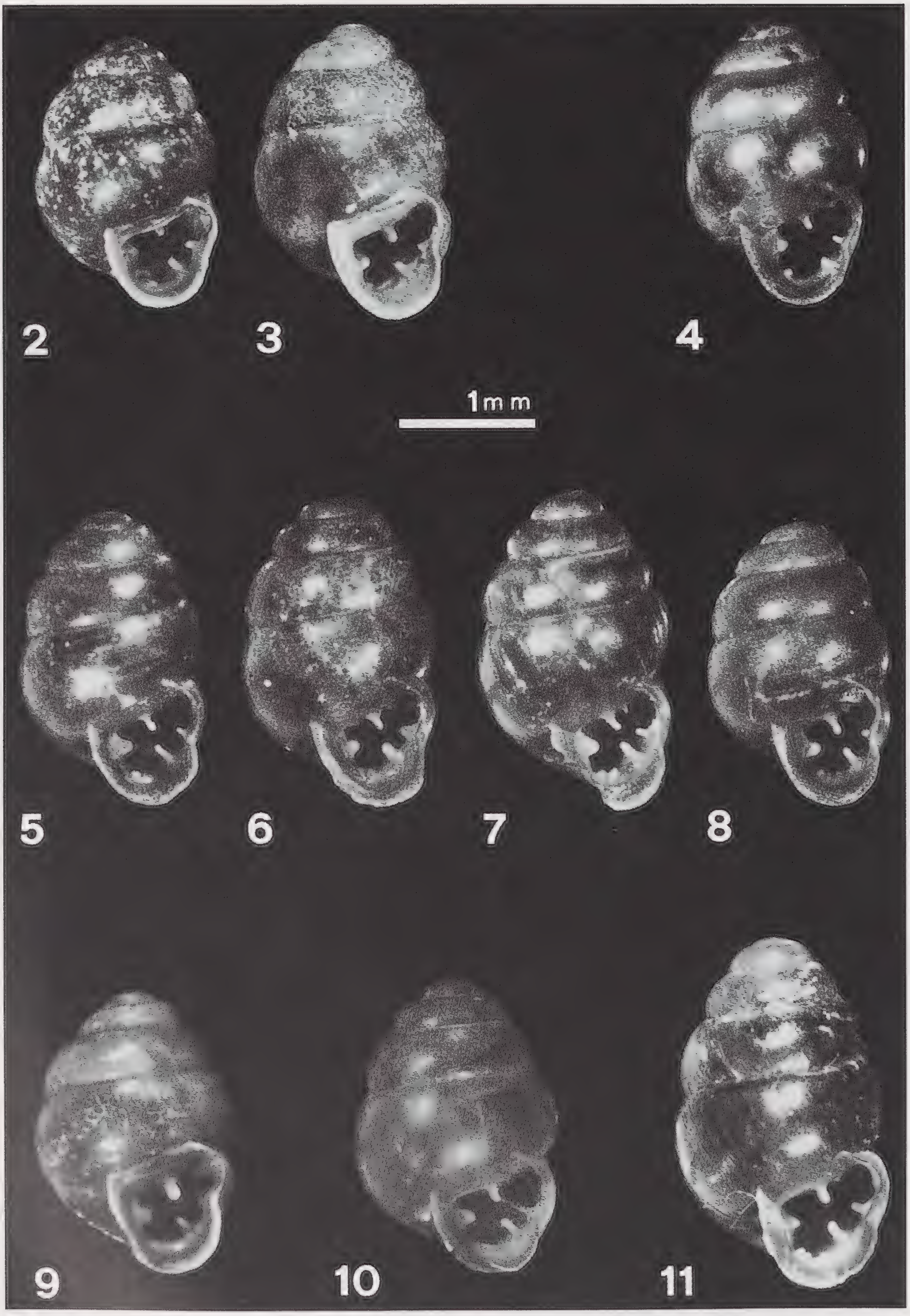
In Italy, recent specimens of *V. moulinsiana* have been reported from 20 sites in ten regions (Aosta Valley, Piedmont, Lombardy, Trentino - Alto Adige, Venetum, Emilia Romagna, Tuscany, Campania, Sardinia and Sicily), but one of these is erroneous (Repetto, 1986). We tried to trace all the specimens referred to in publications, but only those from six localities were found. In five cases they were correctly determined (see Appendix 2). We failed to trace the specimens collected at Aosta [32TLR66 or 32TLR67], San Cristophe [32TLR67] and Quart [32TLR67] (Pegorari, 1883), in the "posature del Tanaro a Govone" [32TMQ36] (Pollonera, 1886), at "Stazzano près de Serravalle" [32TMQ85 or 32TMQ95] (Stabile, 1864; Pini, 1877; Lessona, 1880), "Ponte d'Oléggio" [32TMR74] (Bishop, 1976), "Foce dell'Oglio nei dintorni di Lovere" [32TNR87] (Adami, 1876), Nals [32TPS65], Vilpian [32TPS66], "Monzonegebirge in Fassatal" [32TQS04 or 32TQS14] (Riezler, 1929), "Stra östlich Padua" [32TQR33 or 33TTL63] (Boettger, 1936), in "Tal des Sarno oberhalb Scafati" [33TVF61] (Boettger, 1936) and in the "Madonie" [33SVB18, 33SVB19, 33SVB28, 33SVB29] (Benoit, 1882). Other historical material collected at "Esino" (probably corresponding to Esino Lario, Como [32TNR92]), has been found in the Tommasi collection and other, generically labelled "Sicilia", in the SMF collection. The former actually belongs to this species, but the latter is misidentified (see Appendix 2).

In the last 20 years, field research has produced new records. Fresh shells or live specimens have been found in eight new localities (Lago di Viverone, Torrente Ceno, Molino del Mugnone, Fosso delle Filicaie, Fosso Elvella, Fiume Calore, Fiume Marepotamo and Fiume Coghinas) and one already reported in the literature (Fiume Tacquisara). Old shells, perhaps Holocene specimens, eroded from sediment, have been found in six other localities (Valle degli Acquastrini, Fiume Pecora, Fosso Rigo, Fiume Orcia, Pian di Giuncheto and L'Aiso). If the recent report by Bishop (1976) is considered, *V. moulinsiana* is currently recorded from ten sites, in six regions (Piedmont, Emilia Romagna, Tuscany, Campania, Calabria and Sardinia) (Fig. 1). The historical and present distributions of *V. moulinsiana* are probably wider. Material from 12 historical sites in which the species was recorded before the 1970s has not been checked and large territories have still not been carefully investigated. The large number of sites in Tuscany probably only reflects the amount of field research done in this region.

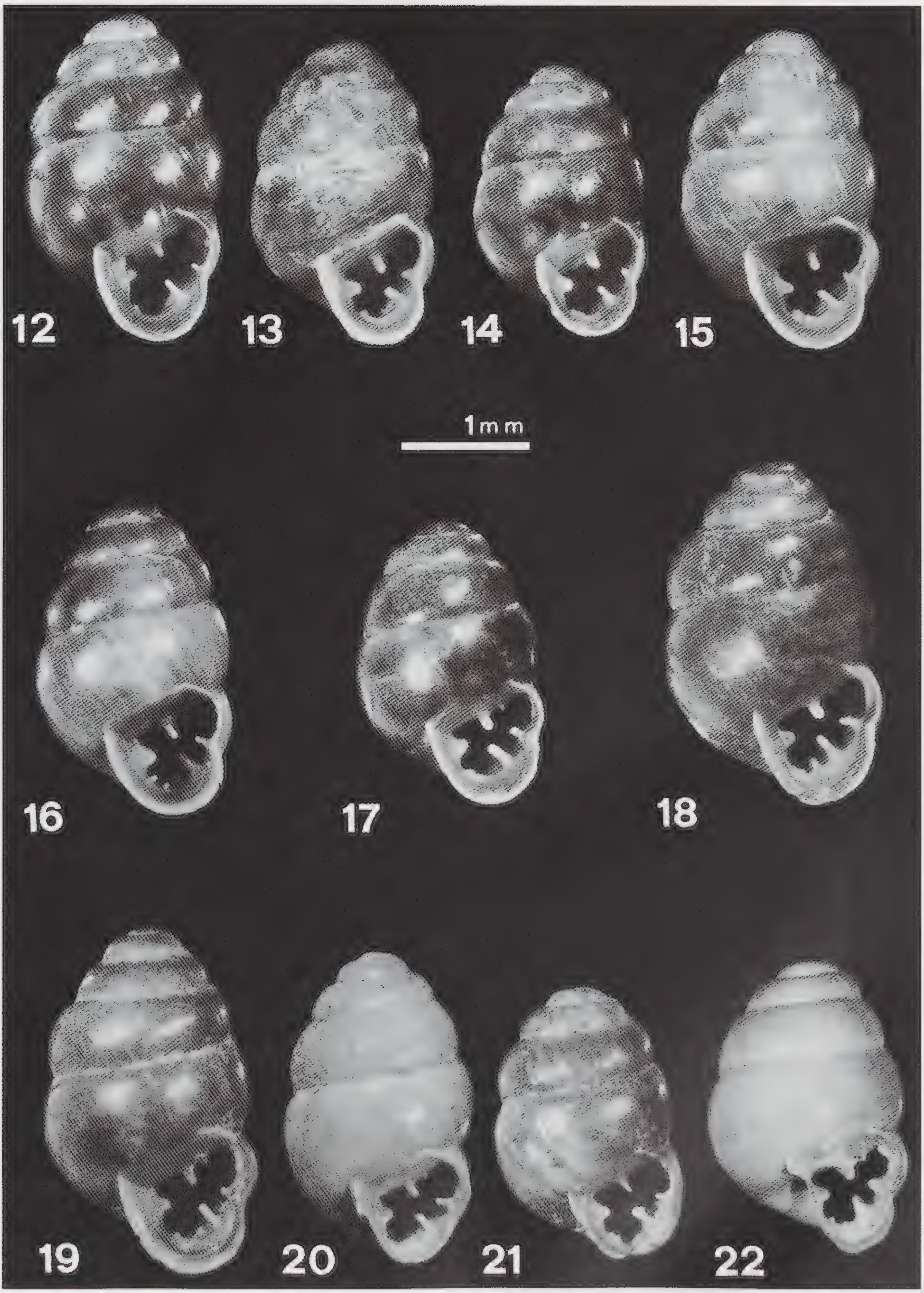
Despite its wide distribution, the species is very rare and extremely localized. The rarity is testified by the scarcity of specimens collected from the river debris (this method usually brings to light most species living in riparian habitats, often, with abundance of specimens). An attempt to collect more specimens from a suitable Tuscan site (Fosso delle Filicaie) by examining a large quantity of river debris was fruitless.

Collins & Wells (1987), Pokryszko (1990), Wells & Chatfield (1992) and Drake (1999) summarize the ecological information on the species as restricted to long-established calcareous wetlands, usually bordering rivers, lakes, marshes, fens, reed beds and other tall monocotyledons and requiring high humidity and warmth. The ecological features of the Italian sites where *V. moulinsiana* lives are not known in detail. In fact, much of the material examined is historical and without any useful indication on the site in which the specimens were collected and, with only one exception (Lago di Viverone), all the other material was sorted out of river debris. Notwithstanding this, some sites of central Italy seem unusual. For example, Fosso Elvella is a seasonal stream with scattered riparian vegetation in shale hills with sheep grazing, farms and coppices of deciduous mesophilous broadleafs and Valle degli Acquastrini is an arid calcareous area with Mediterranean-type vegetation and a small seasonal stream.

*V. moulinsiana* has been regarded as "Vulnerable" by Wells & Chatfield (1992) and "Lower Risk: conservation dependant [LR cd]" by Bailie & Groombridge (1996), and in



**Figs 2–11** Shells of Italian specimens of *Vertigo moulinsiana* (Dupuy, 1849) "Posature del Po a Torino" (Torino, Torino), 32TLQ99 (Pollonera collection, MZUT no. 124) (**2–3**), "Esino", probably corresponding to Esino Lario (Esino Lario, Como), 32TNR92 (ex Tommasi collection, FGC) (**4–8**), "Valli di S. Anna presso Modena" (San Cesario sul Panaro, Modena), 32TPQ5937, D. Pantanelli leg. 11.1883 (Paulucci coll.; MZUF no. 6152) (**9**), "Montramito presso il laghetto", 32TPP05 (Paulucci collection, MZUF no. 6153) (**10**) and "Valle del Taquisara" (Gairo Taquisara, Cagliari), 32TNK31, C. Caroti leg. 1879 (Paulucci collection, MZUF no. 6150) (**11**).



**Figs 12–22** Shells of Italian specimens of *Vertigo moulinsiana* (Dupuy, 1849) from "Boschetti della Cavallara a Castelgoffredo" (Castel Goffredo, Mantova), 32TPR11 (ex Tommasi collection, FGC) (**12–18**), debris of Fosso delle Filicaie, San Giusto in Salcio (Gaiole - Radda in Chianti, Siena), 32TPP9115, G. Manganelli leg. 28.11.92 (**19**), debris of Fosso Rigo, between Poder Nuovo and Montechiaro (Siena, Siena), 32TPP9400, G. Manganelli leg. 3.1.93 (**20**), debris of Fosso Elvella, Podere la Cascina (S. Casciano dei Bagni, Siena), 32TQN3044, G. Manganelli, L. Favilli & M. Brezzi leg. 18.3.93 (**21**) and L'Aiso (Bevagna, Perugia), 33TUH0459 L. Favilli & G. Manganelli leg. 30.9.92 (**22**).

Italy as "Vulnerable [VU: B2a, B2b]" by Manganelli *et al.* (2000). The species is in decline due to destruction of habitat, especially the cultivation of wetlands, destruction of riparian environments and changes in water levels caused by human activity (drainage, irrigation, channelling, etc.). D. Franchini (unpublished) states that most of the wetlands near Castel Goffredo, where the species was collected in the last century by A. Tommasi, no longer exist, destroyed by draining work for an industrial estate. Beside river and wetland alteration, another threat may be fertilizers and pesticides.

At present, it is impossible to propose an action plan for the conservation of the Italian populations because of their small size and fragmented distribution. The only thing to do at this stage is to continue to gather further information on the distribution and size of Italian populations of the species.

## TAXONOMY OF ITALIAN *VERTIGO MOULINSIANA*

Italian specimens of *V. moulinsiana* vary widely in shell shape and size and the structure of the apertural armature (no specimen has ever been studied anatomically). Shell shape is always ovate but the spire is more or less elongate (Figs 2–22). Shell size ranges from 2.09 to 2.84 mm in height and 1.41 to 1.69 mm in width (Height/Diameter 1.39 to 1.76) (Table 1; Fig. 23). The aperture always has the four main teeth: the parietal, columellar, lower and upper palatal teeth, and some accessory denticles. However, apart from the angular (found in 35% of the specimens examined) and suprapalatal (occasionally present) ones, the interpretation of those in subcolumellar-infrapalatal position is controversial. The subcolumellar-basal position is often occupied by a small denticle (Figs 4, 12–13) or two knob-like or slightly pointed denticles that are joined or very close to each other (Figs 6, 11, 15, 17–18, 21). The two denticles are sometimes distinct and one on the left (in apertural view) actually occupies the subcolumellar position (Fig. 16). Exceptionally, between the one or two denticles in subcolumellar-basal position and the lower palatal tooth there is another denticle, which may be more (Fig. 15) or less developed (Fig. 8). Although it is reasonable to interpret the latter as infrapalatal, the others are more difficult to interpret because their number, shape, size and position are not constant. For instance, three denticles may represent subcolumellar, basal and infrapalatal teeth or a two-pointed basal and infrapalatal teeth; two denticles, the subcolumellar and the basal teeth or a two-pointed basal tooth or the basal and the infrapalatal teeth; one denticle the subcolumellar or the basal one. Pilsbry (1919) denied the existence of a subcolumellar, but it was claimed by earlier authors.

The Italian specimens have a greater size range than that previously recognized for the species (height: 2.5–2.7 mm, according to Butot & Neuteboom, 1958; 2.16–2.69 mm, according to Waldén, 1966; 2.2–2.7 mm, according to Kerney *et al.*, 1983; 2.25–2.73 mm, according to Pokryszko, 1990). Some of the smallest Italian specimens fall in the size range of *Vertigo lilljeborgi* Westerlund, 1871. This species used to be regarded as a junior synonym of *V. moulinsiana*, but lately this synonymy is only accepted by Schileyko (1984). Conchologically the main difference between the two species is the smaller size of *V. lilljeborgi* (height: 1.84–2.23 mm, according to Waldén, 1966; 1.9–2.2 mm according to Kerney *et al.*, 1983; 1.73–2.05 mm, according to Pokryszko, 1990; for *V. moulinsiana*, see above). Pokryszko (1990) argues that *V. lilljeborgi* also differs in shell and anatomical features. The anatomical differences consist in the presence (not constant) of a swelling at the end of the first hermaphrodite duct and a triangular-profiled albumen gland in *V. moulinsiana* (absence of a swelling at the end of the first hermaphrodite duct and a tongue-shaped albumen gland in *V. lilljeborgi;* Pokryszko, 1990). Apart from minor differences in the form of the peristome, the shape of the shell and the apertural arma-

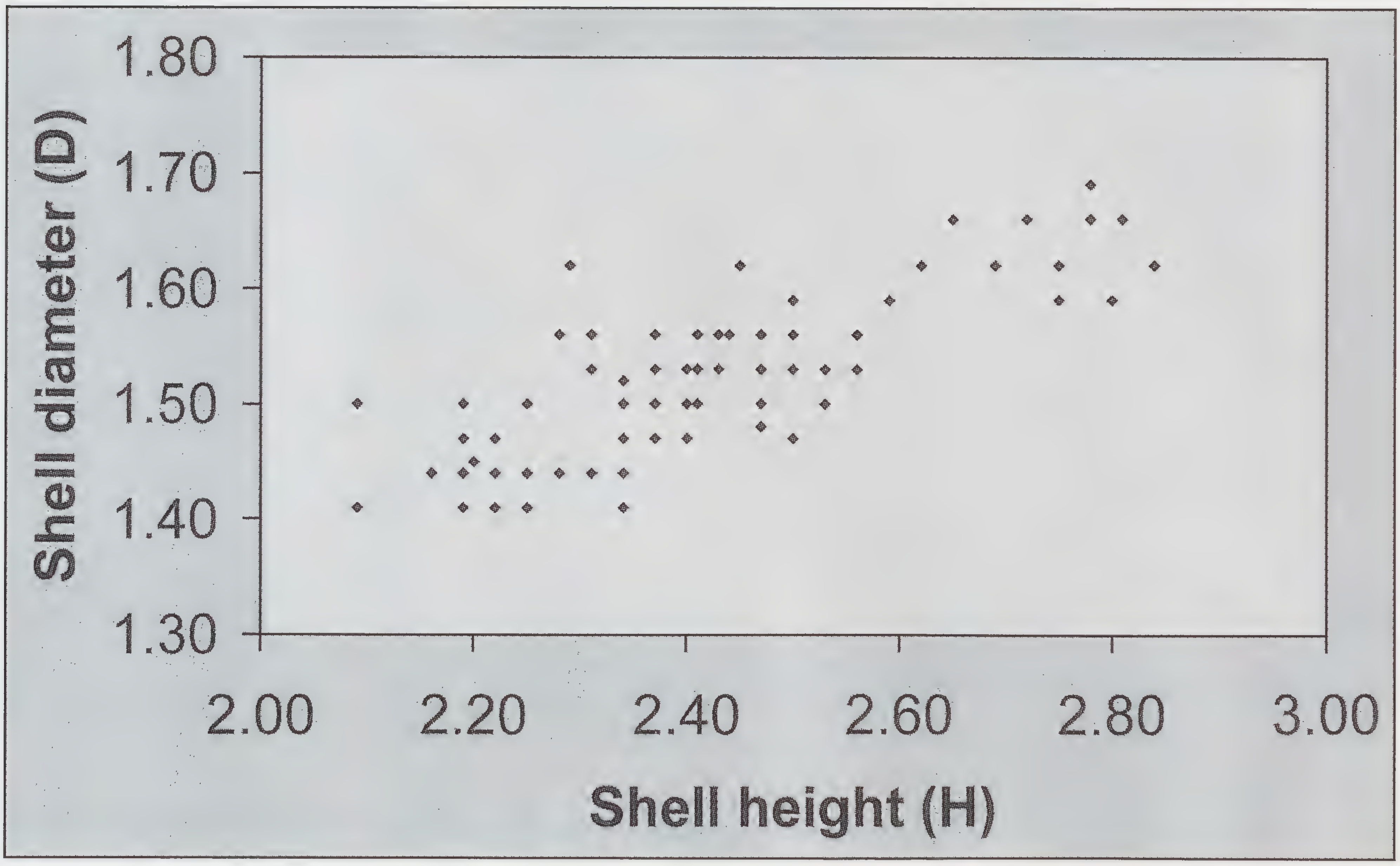


**Fig. 23** Distribution of shell height (H) and diameter (D) (in mm) of the Italian specimens of *Vertigo moulinsiana* (Dupuy, 1849).

ture is the same in the two species (for *V. lilljeborgi*, see Waldén, 1966: Figs. 4a–c; Pokryszko, 1990: Fig. 70–72). We excluded the possibility that some of the smallest Italian specimens could be assigned to this species, because they always belong to populations in which most of the specimens are in the size range of *V. moulinsiana*. It is significant that one of the smallest Italian specimens (height: 2.19 mm) is from the same site ("Valli di Sant'Anna") as one of the largest Italian specimens (height: 2.84 mm). Obviously, with the few specimens at our disposal, we cannot pretend to be absolutely right. In such cases, only genetic research can provide an answer.

It is possible that more than one biological species or reproductively isolated strains coexist in the morphospecies *V. moulinsiana*, especially in view of the small size of most populations and their mutual isolation over a wide geographical area (as for the concept of morphospecies, see Giusti & Manganelli, 1992). Aphally, a phenomenon which is described as frequent in *V. moulinsiana* populations (Steenberg, 1925; Pokryszko, 1987, 1990), suggests that this hypothesis may be true. In fact, aphally is common in many groups of the pulmonates, especially orthurethrans, in which cryptic/semicryptic species or reproductively isolated strains have been demonstrated to exist (Armbruster & Schlegel, 1994; Armbruster, 1997; Jordaens *et al.*, 1998).

## SOME REMARKS ON THE GEOGRAPHICAL AND STRATIGRAPHICAL DISTRIBUTION OF *VERTIGO MOULINSIANA*

Zilch & Jaeckel (1962) regarded the distribution of *V. moulinsiana* as Holoarctic because of its alleged synonymy with the Nearctic *Vertigo ventricosa* var. *eliator* Sterki, 1894, but this synonymy is now no longer accepted. Its synonymy with the northern European *V. lilljeborgi* has also recently been rejected (Pokryszko, 1990). As currently accepted, *V.*

## TABLE 1

Shell dimensions (mean, standard deviation and range) in the Italian *Vertigo moulinsiana* (Dupuy, 1849). The dimensional parameters (shell height and maximum shell diameter) were measured using a millimetric lens on a Wild M5A microscope. For complete details on the localities, see Material examined.

| **Locality** | **Height** | **Diameter** | **H/D** | **n** |
|---|---|---|---|---|
| "Po a Torino" | 2.22<br>(2.09–2.37) | 1.49<br>(1.41–1.56) | 1.49<br>(1.46–1.52) | 3 |
| Lago di Viverone | 2.32<br>(2.29–2.34) | 1.57<br>(1.52–1.62) | 1.48<br>(1.41–1.54) | 2 |
| "Esino" | 2.29 ± 0.10<br>(2.19–2.50) | 1.45 ± 0.04<br>(1.41–1.53) | 1.58 ± 0.04<br>(1.50–1.67) | 13 |
| "Boschetti della Cavallara a Castelgoffredo" | 2.46 ± 0.13<br>(2.31–2.78) | 1.53 ± 0.06<br>(1.41–1.69) | 1.61 ± 0.04<br>(1.51–1.70) | 50 |
| "Mantua" (SMF 109644) | 2.34<br>(2.31–2.37) | 1.50<br>(1.44–1.56) | 1.56<br>(1.48–1.63) | 2 |
| Torrente Ceno | 2.20 | 1.45 | 1.52 | 1 |
| "Valli di S. Anna (prov. di Modena)" and "Valli di S. Anna presso Modena" | 2.61<br>(2.19–2.84) | 1.57<br>(1.50–1.62) | 1.66<br>(1.46–1.76) | 3 |
| "Dintorni di Modena" | 2.28<br>(2.22–2.41) | 1.50<br>(1.47–1.56) | 1.52<br>(1.51–1.54) | 3 |
| "Montramito presso Viareggio", "Prati di Montramito" and "Montramito presso il laghetto" | 2.28 ± 0.15<br>(2.09–2.53) | 1.47 ± 0.04<br>(1.44–1.56) | (1.53 ± 0.07<br>(1.39–1.65) | 11 |
| Fosso delle Filicaie | 2.81 | 1.66 | 1.69 | 1 |
| Fosso Rigo | 2.53 | 1.50 | 1.69 | 1 |
| Fosso Elvella | 2.28 | 1.56 | 1.46 | 1 |
| Pian di Giunchetto | 2.19 | 1.44 | 1.52 | 1 |
| L'Aiso | 2.45 | 1.62 | 1.51 | 1 |
| Fiume Calore | 2.37 | 1.56 | 1.52 | 1 |
| Fiume Marepotamo | 2.19 | 1.44 | 1.52 | 1 |
| "Valle del Taquisara" and Riu Taquisara | 2.61<br>(2.53–2.73) | 1.56<br>(1.53–1.59) | 1.67<br>(1.64–1.73) | 3 |

*moulinsiana* has a very local distribution in central southern Europe from the Atlantic to Georgia and Azerbaijan and in western North Africa. It has been reported from Ireland, Britain, The Netherlands, Belgium, France, Spain, Morocco, southern Sweden, Denmark, Germany, Switzerland, Austria, Italy, Lithuania, Poland, Slovakia, Hungary, Bulgaria, Ukraine, Georgia and Azerbaijan (Kerney *et al.*, 1983; Pokryszko, 1990; Seddon & Holyoak, 1993; Schileyko, 1984; Turner *et al.*, 1998; Kerney, 1999; Drake, 1999). The species is also recorded from Armenia (Akramowski, 1976), but it is not clear from the figure (Akramowski, 1976: Pl. 5, fig. 50) if this material actually belongs to *V. moulinsiana*. If the synonymy between *V. moulinsiana* and *V. codia* (Seddon & Holyoak, 1993) is demonstrated, the distribution of the species will also include Algeria. In northern Europe, *V. moulinsiana* is considered to be replaced by *V. lilljeborgi* (Kerney *et al.*, 1983; Pokryszko, 1990).

No records of the species before the Quaternary has emerged, but it was widespread during the Late Pleistocene and Holocene in many different countries (Zilch & Jaeckel, 1962). No fossil record exists for Italy, if our possibly Holocene records are excluded. In fact the report by Esu (1981) from the Lower–Middle Pleistocene of Torrente Cavaliere (Isernia, Molise) is based on a misidentified specimen of *Vertigo antivertigo* (Draparnaud, 1801).

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## APPENDIX 1

### REPORTS OF *VERTIGO MOULINSIANA* FROM ITALY (THOSE BASED ON MISIDENTIFIED SPECIMENS ARE MARKED WITH AN *).

*Vertigo Moulinsiana* – Stabile, 1864: 104 ("Val de la Scrivia: Stazzano près de Serravalle").

*Vertigo antivertigo* – Tommasi, 1875: 175, non Draparnaud, 1801, fide Adami (1876) e Pini (1877) ("Sotto le foglie morte, in luoghi assai umidi, sul margine di alcune sorgenti, e lungo alle ripe dei fossi, in prossimità a Castelgoffredo. Non troppo comune").

*Vertigo Moulinsiana* – Adami, 1876: 59 ("... nei prati paludosi presso la foce dell'Oglio nei dintorni di Lovere" ... "il Cav. Tommasi avea già da qualche anno trovato questa specie nei dintorni di Castelgoffredo Mantovano ...").

*[Vertigo Moulinsiana]* – Pini, 1877: 493–496 ("... Sicilia ... Serravalle Scrivia in Piemonte ... Cavallara presso Castelgoffredo, circondario di Castiglione delle Stiviere, provincia di Mantova").

*Vertigo moulinsiana* – Lessona, 1880: 334 ("R.P. Alluvioni del Po a Torino (Pollonera). V.T. V. Scrivia: Stazzano presso Serravalle 150m circa (Ferrari)").

*Pupa moulinsiana* – Benoit, 1882: 98 ("Vive sulle Madonie").

*Vertigo Moulinsiana* – Paulucci, 1882: 284–285 ("Abita la valle del Tacquisara ... Castelgoffredo in Lombardia ... nei prati di Montramito presso Viareggio").

*Vertigo Moulinsiana* – Pegorari, 1883: 177 ("Raccolsi pochi esemplari di questa specie sul versante sinistro della Dora, nelle località citate per la specie precedente [... nel piano di Aosta all'est della città, nel piano di S. Cristophe ed in quello di Quart, sulla sinistra della Dora (550 a 600) ...]. Sembra rara in tutto il Piemonte poiché il Lessona la cita solamente delle alluvioni del Po a Torino e della valle Scrivia, a 150 m").

*V[ertigo]. (Dex[iogira].) moulinsiana* – Pollonera, 1885: 14 ("R. al. Contorni d'Aosta (Pegorari, l.c.). R. ap. V. Scrivia, Stazzano presso Serravalle. Trovansi pure nelle alluvioni del Po a Torino. Sempre rarissima").

*V[ertigo]. (Dexiogira) moulinsiana* – Pollonera, 1886: 2 ("Posature del Tanaro a Govone").

*Pupa [(Alaea)] moulinsiana* – Picaglia, 1891: 144 ("Valli di S. Anna (Fiori)").

**Pupa (Alaea) moulinsiana* – Picaglia, 1893: 115 ("Sestola [1100 m] abbondantissima"). Misidentified specimens of *Vertigo pygmaea* (Draparnaud, 1801) (material in Monterosato collection, MCZR).

*V[ertigo]. moulinsiana* – Riezler , 1929: 135 ("In Südtirol bis zur Schneegrenze ansteigend, bisher nur bekannt von Nals und Vilpian (Alber) und vom Monzonegebirge in Fassatal; hier bis knapp unter die Schneegrenze aufsteigend (Grd.)").

*Vertigo moulinsiana* – Ehrmann, 1933: 40 ("... aus Sizilien, ... aus Anschwemmungen des Po bei Turin, aus dem Aostadal, vom Iseosee, aus dem Fassatal, ...").

*Vertigo (Vertigo) moulinsiana* – Boettger, 1936: 101–113 (p. 103: "Auch in Südtirol ist sie en einigen Stellen nachgewiessen worden (32 [Riezler, 1929], p. 135). Vom dem Abfall der Alpen zur Lombardei, Südschweiz und nach Piemont hat man *Vertigo (vertigo) moulinsiana* Dup. bisher noch nicht festgestellt. In Piemont ist sie jedoch in der Prov. Alessandria vom Abfall des Ligurishen Apennin von Stazzano bei Serravalle im Tal der Scrivia bekannt (38 [Stabile, 1864], p. 104)"; p. 110: "Am gleichen Biotop fand ich sie 1930 bei Stra östlich Padua in Oberitalien; der nächste Bekannte Fundort ist der von N. Pini angegebene bei Castelgoffredo unweit Mantua (28 [Pini, 1877], p. 495). Ein dritter Fundfort ist unsicher. An einem mit Sumpfgewächsen umsäumten Tümpel im Tal des Sarno oberhalb Scafati südöstlich les Vesuvs sammelte ich im Jahre 1933 eine einzelne Schnecke, die ich als *Vertigo (Vertigo) moulinsiana* Dup. ansprach, die jedoch bei der Prüfung zu Boden fiel und nicht wiedergefunden werden konnte; weiteres Material wurde nicht angetroffen").

*Vertigo moulinsiana* – Butot & Neuteboom, 1958: 52–63 (p. 53: "Italië. - Aostadal, Iseomeer, Fassadal Zuid Tirol, Sicilië (Ehrmann, 1933, p. 40); Scriviadal, bij Padua, Sarnodal (Boettger, 1936, p. 103,

110); bij Mantua (Pini, 1876, p. 495)").

*Vertigo moulinsiana* – Alzona, 1971: 63 ("Italia, Sicilia, Sardegna").

*Vertigo moulinsiana* – Bishop, 1976: 273 ("MR74 Ponte d'Oleggio").

*Vertigo moulinsiana* – Bishop, 1980: 204 (provinces of Alessandria, Aosta, Novara).

**Vertigo moulinsiana* – Esu, 1981: 96, Fig. 2G ("argille pleistoceniche della fase erosiva di passaggio fra il Pleistocene inferiore e il Pleistocene medio (T. Cavaliere, Isernia, Italia centro-meridionale)"). Misidentified specimen of *Vertigo antivertigo* (Draparnaud, 1801) (Material in the Istituto di Geologia e Paleontologia dell'Università di Roma (Italy) (IGP 0700/1/M)).

*Vertigo moulinsiana* – Palazzi, 1985: 22 (provincia di Modena).

**Vertigo moulinsiana* – Repetto, 1985: 256, Pl. 1, fig. 9 ("Posatura detritica vegetale del Fiume Belbo"). Misidentified specimens of *Vertigo pygmaea* (Draparnaud, 1801), see Repetto (1986: 214).

*Vertigo moulinsiana* – Collins & Wells, 1987: 123–148 ("Italy: Rare. Sicily, Padua, Mantua (Alessandria, Aosta, Novara) (Butot & Neuteboom, 1958)").

*Vertigo moulinsiana* – Wells & Chatfield, 1992: 99–101 ("Italy: Rare. Sicily, Padua, Mantua (Butot & Neuteboom, 1958); provinces of Alessandria, Aosta, Novara (Bishop, 1980); Modena, but not recorded in last 10 years (Palazzi, 1983 [= 1985]").

## APPENDIX 2

### MATERIAL EXAMINED

The material examined is listed as follows: locality; municipality and province in parenthesis; UTM reference; collector(s) and date; number of specimens and collection where it is deposited in parenthesis. Locality names and UTM references were according to the official 1:25,000, 1:50,000 or 1:100,000 scale maps of Italy (series M 891, 792, 691).

The material examined is in the Dipartimento di Scienze della Terra, Università La Sapienza, Ple. Aldo Moro 5, 00100 Roma, Italy (IGP), the Museo Civico di Zoologia, Via Aldrovandi 18, 00197 Roma, Italy (MCZR), the Museo Regionale di Scienze Naturali, Via G. Giolitti 36, 10123 Torino, Italy (MZUT), the Museo Zoologico "La Specola", Sezione del Museo di Storia Naturale dell'Università di Firenze, Via Romana 17, 50125 Firenze, Italy (MZUF) and the private collections of M. Bodon (Via delle Eriche 100/8, 16148 Genova, Italy MBC), S. Cianfanelli (P.le Porta Romana 13, 50125 Firenze, SCC), D. Franchini (Via Cremona 37, 46100 Mantova, Italy, DFC) and F. Giusti (Dipartimento di Biologia Evolutiva, Via Mattioli 4; I-53100 Siena; Italy, FGC).

**Recent specimens (fresh shells and live specimens) of *Vertigo moulinsiana* (Dupuy, 1849):**
Piedmount – LQ99) "Posature del Po a Torino" (Torino, Torino), 32TLQ99, C. Pollonera leg. (3, Pollonera collection, MZUT no. 124). **MR22**) Lago di Viverone (Azeglio, Torino), 32TMR2329, 23, M. Bodon leg. 4.11.90 (3, MBC).

**Lombardia – NR29)** "Esino" probably corresponding to Esino Lario (Esino Lario, Como), 32TNR92 (11, Tommasi collection, DFC; 5 FGC). **PR11**) The following material, though labelled in different ways, probably comes from the same locality where it was collected by A. Tommasi: "Boschetti della Cavallara" (Castel Goffredo, Mantova), 32TPR11: "Boschetti della Cavallara a Castelgoffredo" (275, Tommasi collection, DFC; 7 FGC), "Castelgoffredo (Prov. Mantua)" (15, Boettger collection, SMF 109651), "Castelgoffredo" (42, Paulucci collection, MZUF no. 6151), "Castelgoffredo" (53, Paulucci collection, MZUF no. 6147), "Mantua" (4, Jetschin collection, SMF 109644), "Mantua" (3, Kinkelin collection, SMF 245961).

**Emilia Romagna – NQ84)** Debris of Torrente Ceno, Fornovo di Taro (Fornovo di Taro, Parma), 32TNQ84, M. Bodon leg. 26.4.93 (1, MBC). **PQ53**) The following material is presumed to come from the same locality Sant'Anna (San Cesario sul Panaro, Modena), 32TPQ5937: "Valli di S. Anna (prov. di Modena)" (3, Paulucci collection, MZUF no. 6157), "Valli di S. Anna presso Modena", D. Pantanelli leg. 11.1883 (1, Paulucci coll., MZUF no. 6152) and "Dintorni di Modena" (3, Monterosato collection, MCZR).

**Tuscany – ? PP05)** The following material is presumed to come from the same locality where it was collected by R. Del Prete: Montramito (Massarosa, Lucca), ? 32TPP05: "Montramito presso Viareggio" (2, Monterosato collection, MCZR), "Prati di Montramito" (9, Paulucci collection, MZUF no. 6148). "Montramito presso il laghetto" (7, Paulucci collection, MZUF no. 6153). **PN88)** Debris of a spring near Mulino di Mugnone (Sovicille, Siena), 32TPN8485, M. Bodon & G. Manganelli leg. 28.11.93 (1, FGC). **PP91)** Debris of Fosso delle Filicaie, San Giusto in Salcio (Gaiole - Radda in Chianti, Siena), 32TPP9115, G. Manganelli leg. 28.11.92 (1, FGC). **QN34)** Debris of Fosso Elvella, Podere la Cascina (S. Casciano dei Bagni, Siena), 32TQN3044, G. Manganelli, L. Favilli & M. Brezzi leg. 18.3.93 (1, FGC).

**Campania – WE18)** Monti Alburni, Debris of Fiume Calore, Grotta di Castelcivita (Castelcivita, Salerno), 33TWE1782, S. Cianfanelli & E. Talenti leg. 13.10.94 (1, MZUF no. 11502).

**Calabria – WC96)** Debris of Fiume Marepotamo, Ponte di Soreto (Dinami, Catanzaro), 33SWC9767, S. Cianfanelli & E. Talenti leg. 25.4.94 (1, MZUF no. 10700).

**Sardinia – NK31)** "Valle del Taquisara" (Gairo Taquisara, Nuoro), 32TNK31, C. Caroti leg. 1879 (1, Paulucci collection, MZUF no. 6150); Debris of Riu Taquisara, Stazione di Gairo Taquisara (Gairo Taquisara, Nuovo), 32TNK3911, S. Cianfanelli & E. Talenti leg. 20.5.93 (5, SCC). **ML93)** Debris of Fiume Coghinas near Santa Scala Ruia, 10 Km SW Perfugas (Bortigiadas, Sassari), 32TML9833, S. Cianfanelli & E. Talenti leg. 18.5.93 (1, SCC).

**Possibly Holocene specimens of *Vertigo moulinsiana* (Dupuy, 1849):**

**Tuscany – PM79)** Monte Argentario, debris of Valle degli Acquastrini (Monte Argentario, Grosseto), 32TPM7794, S. Cianfanelli leg. 3.1.97 (1, SCC). **PN46)** Debris of Fiume Pecora, Piano del Padule (Massa Marittima, Grosseto), 32TPN4662, M. Bodon leg. 4.1.96 (1, FGC). **PP90)** Debris of Fosso Rigo, between Poder Nuovo and Montechiaro (Siena, Siena), 32TPP9400, G. Manganelli leg. 3.1.93 (1, FGC). **QN26)** Debris of Fiume Orcia, Podere Molinello (Castiglion d'Orcia, Siena) 32TQN2166, S. Cianfanelli & M. Calcagno leg. 24.11.97 (1, SCC). **QN35)** Debris of a spring at Pian di Giunchetto (Cetona, Siena), 32TQN3559, S. Cianfanelli & M. Calcagno leg. 24.2.96 (2, SCC).

**Umbria – UH05)** L'Aiso (Bevagna, Perugia), 33TUH0459 L. Favilli & G. Manganelli leg. 30.9.92 (1, FGC).

**Misidentified specimens of *Vertigo moulinsiana* (Dupuy, 1849):**

**Emilia Romagna** – "Sestola" (11 determined as *Pupa moulinsiana;* Monterosato collection, MCZR) = *Vertigo pygmaea* (Draparnaud, 1801).

**Molise** – "Pleistocene clays referable to the erosional phase that marks the boundary between the Lower Pleistocene and Middle Pleistocene" exposed along Torrente Cavaliere (Isernia)" (1 determined as *Vertigo moulinsiana* by Esu, 1981, IGP 0700/1/M) = *Vertigo antivertigo* (Draparnaud, 1801).

Sicily – "Sicilia" (3 determined as *Pupa Mondelli* and revised as *V. moulinsiana*, SMF 54952/3) = *Vertigo antivertigo* (Draparnaud, 1801) (2) and *Columella* sp. (1).

# *COLUMELLA* IN SUB-SAHARAN AFRICA: A RANGE EXTENSION OF OVER 4000 KILOMETRES?

P. TATTERSFIELD[1], C.R.C. PAUL[2] & J.A. ALLEN[3]

*Abstract* *Three shells of a small vertiginid land snail were collected in Afromontane Rain Forest at an altitude of 2215–2269 m in the Rwenzori Mountains, Uganda, in 1996. The material has tentatively been identified as* Columella aspera *Waldén. The record represents the first report of the genus* Columella *from Africa.*

*Key words* *Vertiginidae,* Columella aspera, *Rwenzori, Afromontane Forest, Uganda*

## INTRODUCTION

The vertiginid genus *Columella* Westerlund 1878 has a mainly Holarctic distribution (Forcart, 1959), with the majority of species reported from Eurasia extending as far east as Japan, and in North America. There are 2 widespread species in Britain, *C. aspera* Waldén and *C. edentula* (Drap.) (Paul, 1975), and another (*C. columella* (v. Martens)) in continental Europe, mainly in Scandinavia and the Alps. Elsewhere in Europe, *C. edentula* has been reported from Iceland and the Arctic in Scandinavia, southwards to Mediterranean countries where it is local and often montane. Fossil records of *Columella columella* indicate that it was widespread in the lowlands of west and central Europe during cold stages in the Pleistocene, and *C. alticola,* which maybe synonymous (Forcart, 1959), was likewise distributed across North America. *Columella columella* is now mainly restricted to montane and higher latitudes in Europe. *Columella aspera* has been reported as far south as Corsica (Holyoak, 1983). One species, *C. gutta* (Benson, 1864) is known from India (from a single shell collected in the Spiti Valley, Kunawar) and there are several species known in North America, with one reported as far south as Nicaragua (Likharev and Rammel'meier, 1962).

The main characters separating *Columella* from other minute pupillids are the absence of both apertural thickening on the peristome and apertural dentition. Pilsbry and Cockerell (1933) considered their Congolese *Columella pygmaeorum* to be the first member of the genus to be reported from the Ethiopian region. However, Adam (1954) later reassigned this sinistral species to *Truncatellina,* noting its weak columellar lamella within the aperture and the weakly reflected outer lip of the peristome; this assessment of the generic status of *pygmaeorum* has been followed by Verdcourt (1970, 1983) and van Bruggen (1994). As far as we have been able to establish there have been no authenticated records of the genus *Columella* from either north or sub-Saharan Africa.

In July 1996, 3 specimens of a small vertiginid land-snail were found during a Raleigh International expedition to the Rwenzori Mountains in west Uganda. The material has subsequently been tentatively identified from shell morphology as the European species *Columella aspera* Waldén, and thus represents the first report of this genus from sub-Saharan Africa.

## SITE LOCATION

The specimens were collected from site reference 21.7.97.I, which is located at 29.962ºE,

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0.233ºN, at an altitude of 2215–2260 m in Rwenzori Mountains National Park, on the east side of the Rwenzori Mountains, above the village of Kilembe Mines. The site lies within the Afromontane Forest belt (Hedberg, 1951) and the vegetation was mixed forest/woodland and included stands of the shrub *Mimulopsis* (*c.* 6–7 m tall). Bamboo *(Arundinaria alpina)* and tall trees were uncommon in the area. The site is located near a path, within about 30 m from the River Mulyanbuloi and contains steep slopes and rock cliffs.

## MATERIAL

The 3 shells were extracted from sieved leaf litter collected from the forest floor. Mollusc sampling on the site also included direct searching by 8 people over a period of 2 hours (ie. total of 16 person hours). Using both methods, and in addition to the *Columella* specimens, a total of 33 species represented by 212 specimens were also collected from the site.

Shell measurements are given in Table 1, and Fig. 1 shows SEMs of one shell. The shells have the general form and sculpture of *Columella,* with relatively thin shells, a weak, unreflected and unthickened peristome and an absence of apertural dentition. The shells have been identified as *Columella aspera* by comparing with material collected from a variety of British and other European sites. They fall within the size range of material of *C. aspera* collected from Europe (Paul, 1975) and have the regular radial ribbing characteristic of the species, although this character is perhaps weaker than in the majority of European material. Only dead shells were collected during 1996, and living material of this species of *Columella* is required to confirm its identification as *C.*

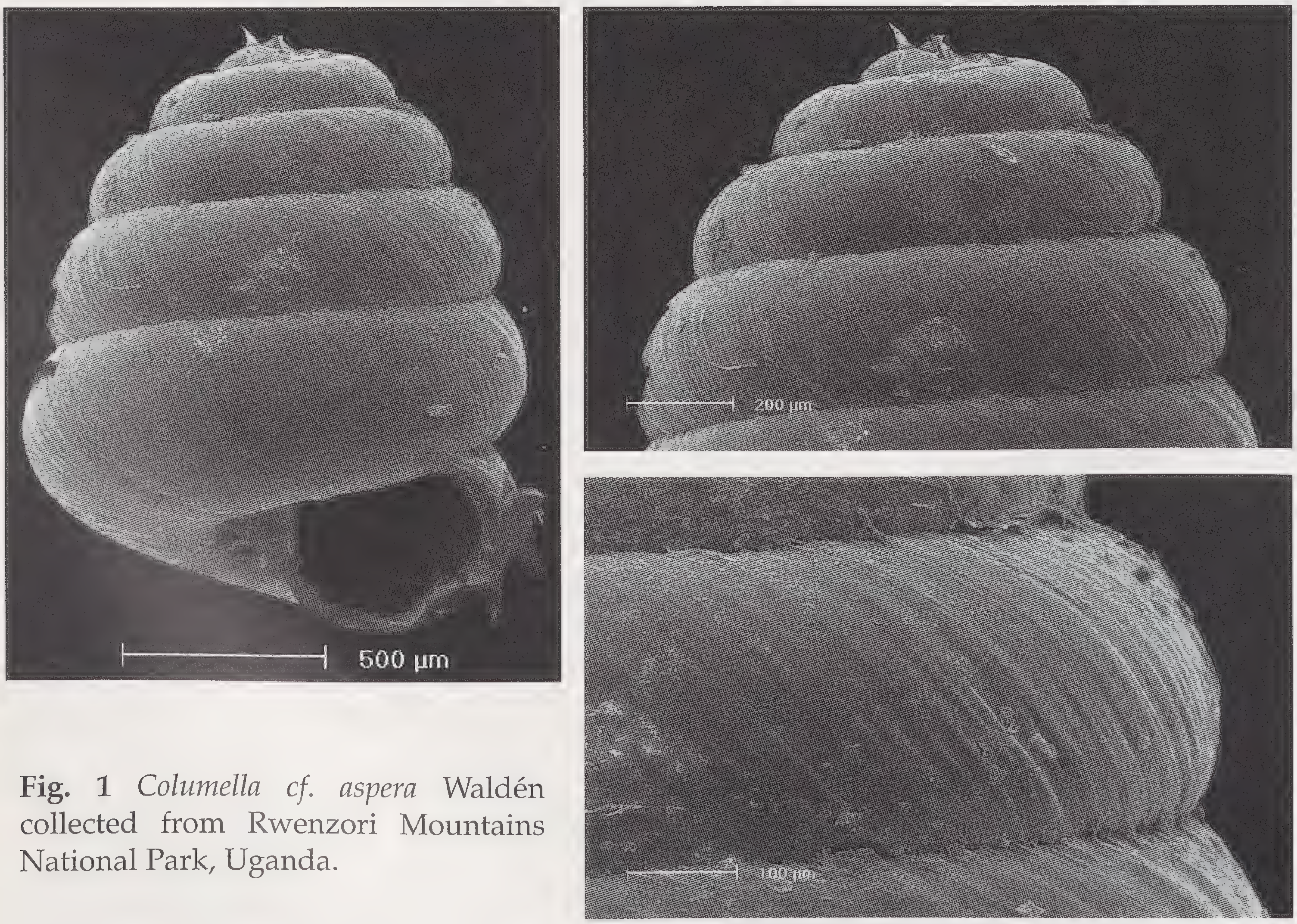

**Fig. 1** *Columella cf. aspera* Waldén collected from Rwenzori Mountains National Park, Uganda.

*aspera* by dissection. The specimens have been deposited in the National Museum and Gallery, Cardiff; Accession Number: NMW.Z.1997.009.

TABLE 1
Shell dimensions of *Columella cf. aspera* collected from the Rwenzori Mountains, Uganda.

| Shell No. | Height (mm) | Diameter (mm) | No. Whorls |
|---|---|---|---|
| 1 | 1.70 | 1.25 | 5.5 |
| 2 | 1.95 | 1.35 | 5.5 |
| 3 | Broken | 1.30 | Broken |

## DISCUSSION

The records for *Columella* reported here would appear to be the first for the genus in continental Africa. The southern-most report of *Columella* in Europe appears to be *Vertigo edentula* Draparnaud from Faro in south Portugal (Nobre, 1913), which is about 5,600 km from Rwenzori. Other southerly European records include *C. columella* from Uludağ and Artvin, Turkey (Schutt, 1996), *C. aspera* from Corsica (France) (Holyoak, 1983) and *C. edentula* from Gerona (Spain) and Macedonia (both pers. comms. M.B. Seddon). The Turkish records are closest to African sites reported, and lie about 4,400 km north of Rwenzori. The other localities lie at least 5000 km from the Rwenzori Mountains. *Columella aspera* and *C. microspora* (Lowe) are listed from Madeira (Waldén, 1983), which lies approximately 6000 km to the north-west of the Rwenzori.

Several other mollusc genera with mainly palaearctic and temperate distributions (eg. *Lauria, Vitrina)* have been reported previously from some of the high East African mountains (see Tattersfield *et al.* in review). Germain (1931) noted this phenomenon and considered the fauna of Mount Kenya to be unusual in this respect, although other temperate latitude taxa have since been reported from other high mountains in East Africa (Verdcourt, 1983; Tattersfield, unpublished). Similar distributional affinities in plants and other groups have usually been explained by long-distance dispersal mechanisms (Kingdon, 1990), in which species associated with cooler climates have dispersed southwards across the elevated Ethiopian dome, and then along the interrupted chain of mountains and other high ground in East Africa. An alternative hypothesis is that a dispersal corridor for such species was present during the cooler and drier periods that have occurred in central Africa during periods of glacial extension at higher latitudes. In the absence of other evidence, such mechanisms would seem to provide plausible explanations for the presence of *Columella* in Rwenzori. However, it is unusual for East African representatives of palaearctic genera and families to be the same as those also occurring at higher latitudes. Thus, if the *Columella* reported here can be confirmed as the widespread European species *aspera,* then this might suggest that colonization has been relatively recent. The remoteness of the locality where the specimens were collected means that inadvertent introduction by Europeans is unlikely.

## ACKNOWLEDGEMENTS

The fieldwork in Rwenzori was supported and made possible by Raleigh International. We thank the many volunteers who helped with snail collecting and logistical support. We are also grateful to Dr Mary Seddon (National Museum of Wales) for unpublished records of *Columella* in Europe.

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# A NEW CORALLIOPHILINE SPECIES FROM THE SOUTHWEST PACIFIC (NEOGASTROPODA: MURICIDAE: CORALLIOPHILINAE)

SADAO KOSUGE[1] & MARCO OLIVERIO[2]

*Abstract* *A new coralliophiline species with striking morphological features is described from several stations sampled in deep waters off New Caledonia. It is compared with related species of* Babelomurex *and* Hirtomurex. *It is currently known only from a restricted area in the south-west Pacific.*

*Key Words* Babelomurex, *New Caledonia, south-west Pacific*

## INTRODUCTION

The species of the genera *Coralliophila, Babelomurex, Hirtomurex, Latiaxis, Quoyula* etc..., have been included in a subfamily Coralliophilinae of the Muricidae, based on molecular data (Oliverio & Mariottini, 2001), which is also supported by morphological affinities with the Rapaninae sensu latu. A revision of the coralliophiline species of the Southwest Pacific is presently carried out by the authors on the material collected during the MUSORSTOM campaigns by the staff of the Muséum National d'Histoire Naturelle (MNHN, Paris) and Institut de Recherche pour le Développement (IRD, formerly ORSTOM, Nouméa). In this ambit, some new taxa have been identified. One of them is worthy of separate publication because of its unique combination of shell features that renders problematic even its attribution to any existing genera. Considering that supraspecific systematics of the Coralliophilinae needs a re-examination by refined morphology and the support of markers independent of morphology, we refrain from describing a new genus for this species and include it within the genus *Babelomurex*, which is commonly considered to include spiny species.

## SYSTEMATIC DESCRIPTION

SUPERFAMILY MURICOIDEA Rafinesque, 1815
FAMILY MURICIDAE Rafinesque, 1815
SUBFAMILY CORALLIOPHILINAE Chenu, 1859

Genus *Babelomurex* Coen, 1922
Type species: *Fusus babelis* Requien,1848

### *Babelomurex neocaledonicus* n. sp.
Figs 1–13

*Holotype* One specimen from (SMIB 4: sta. DW51), 23°41'S, 168°01'E, 245–260 m height 26.8 mm (MNHN).

*Paratypes* (SMIB 8, sta. DW 157), 24°46'S, 168°08'E, 235–300 m, 1 sh (MNHN); (SMIB 8, sta. DW 163), 24°50'S, 168°09'E, 310–460 m, 1 spm (MNHN), 1 spm (AMS, Sydney);

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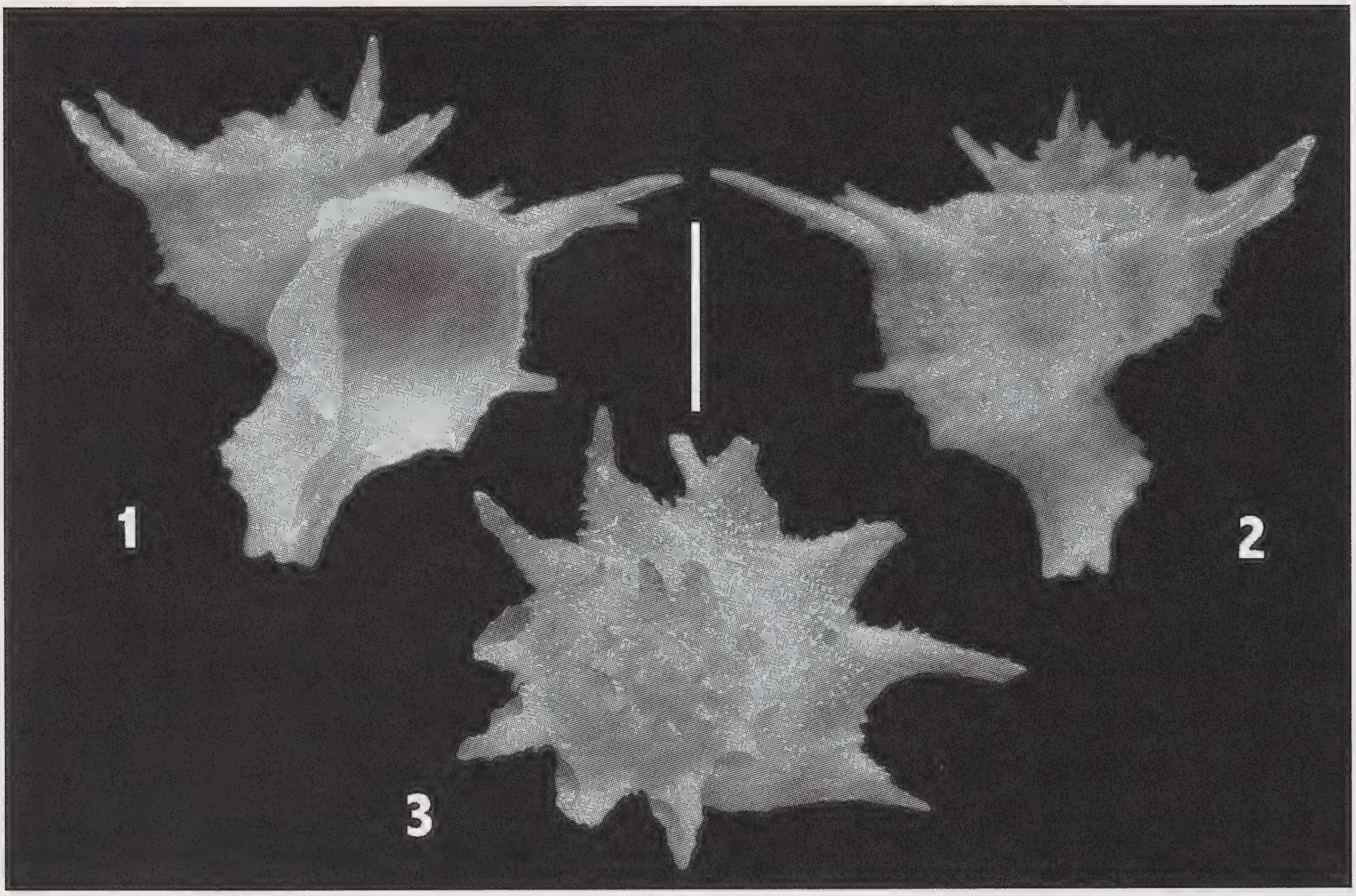
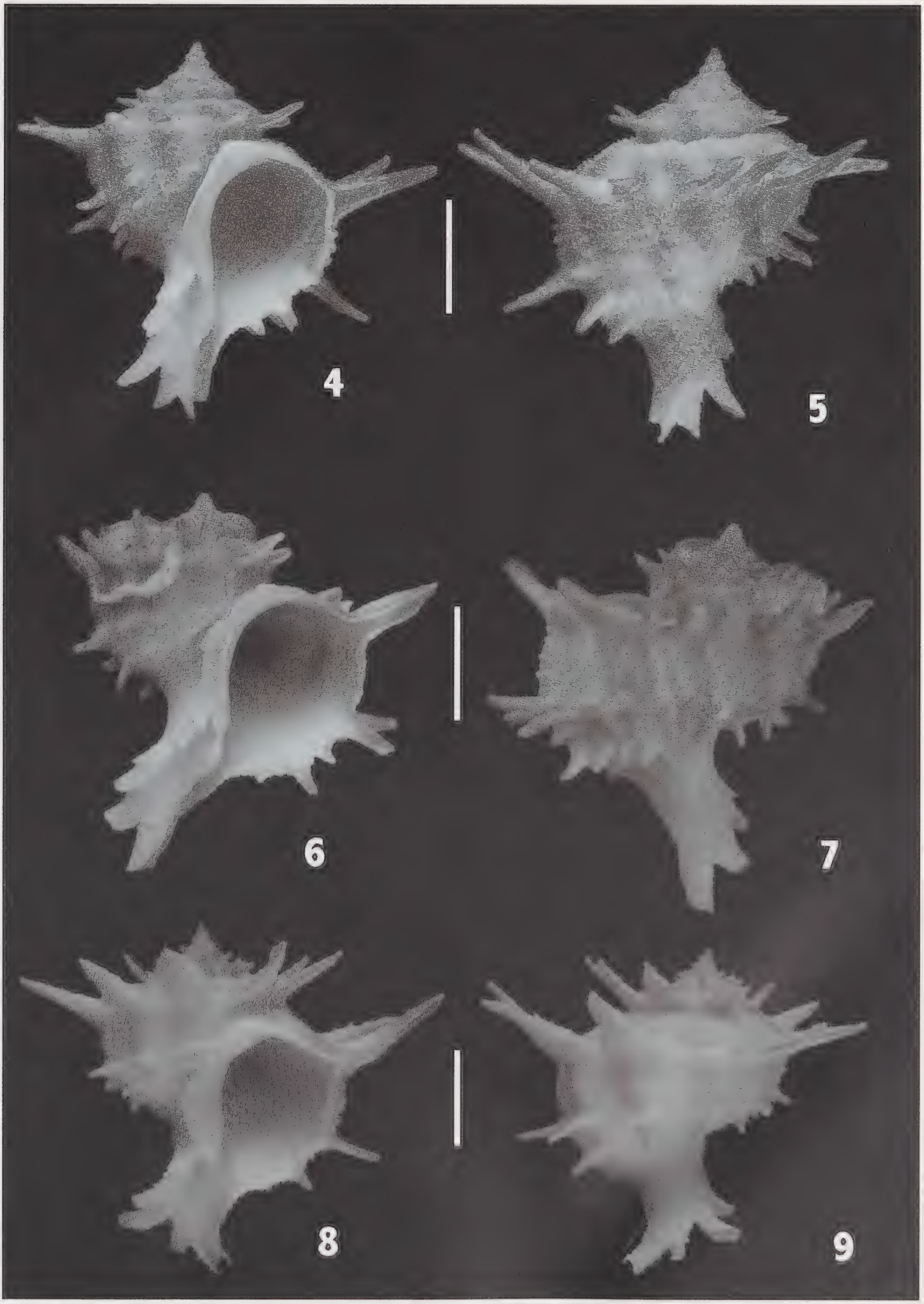


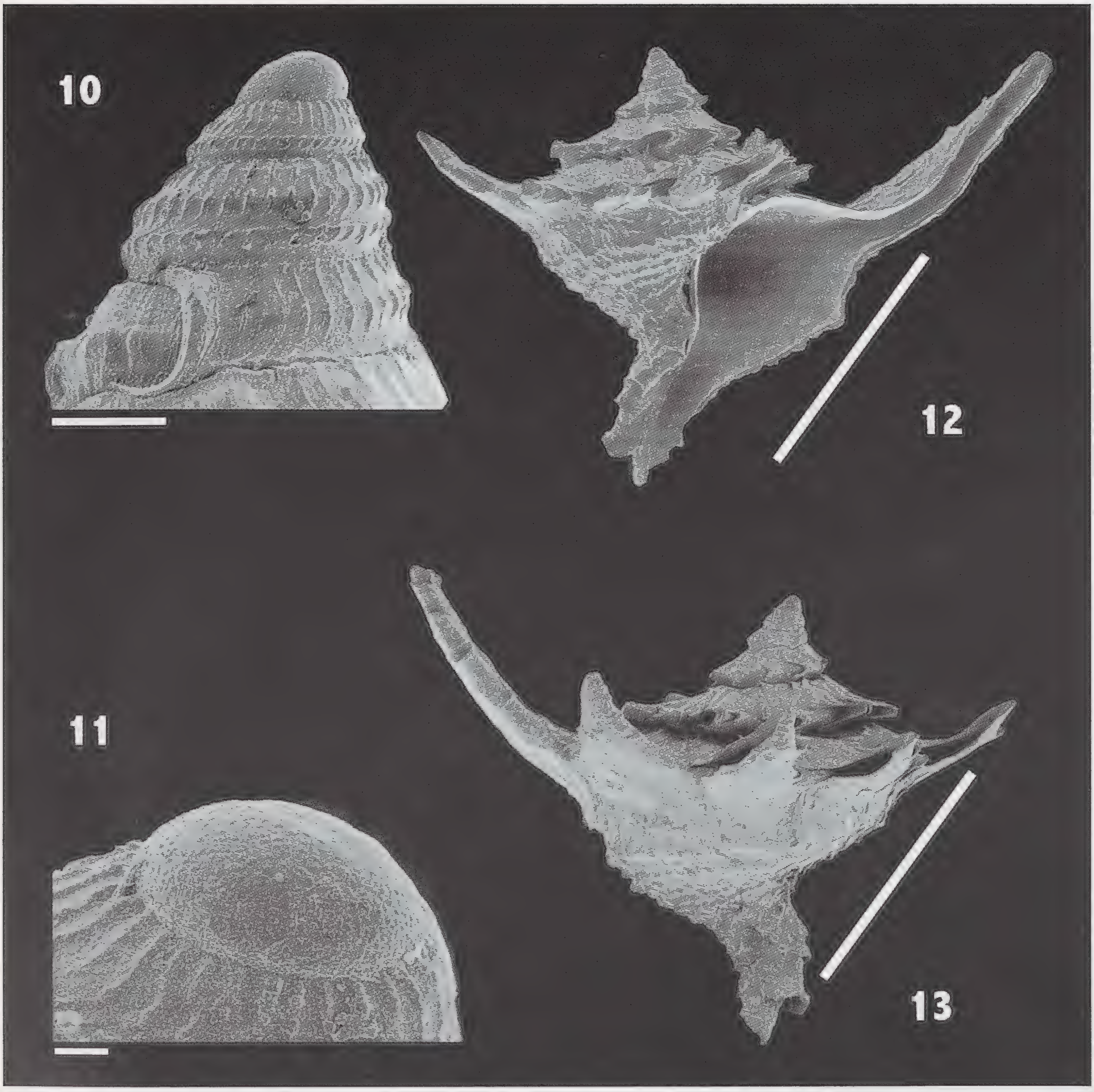
**Figs 1–3** *Babelomurex neocaledonicus* n. sp. holotype, (SMIB 4: sta. DW51), 23°41′S, 168°01′E, 245-260 m, type locality, (MNHN), height 26.8 mm. Scale bar = 10 mm.

(SMIB 8, sta. DW 184), 23°18′S, 168°05′E, 305–320 m. 1 spm (MNHN); (SMIB 8: sta. DW 181), 23°18′S, 168°05′E, 311–330 m, 1 sh (coated for SEM, MNHN), 1 sh (National Museum of New Zealand, Wellington, New Zealand); (SMIB 5: DW70), 23°41′S, 168°01E, 270 m, 1 sh (Natal Museum, Pietermaritzburg, South Africa).

*Other material examined* South New Caledonia, SMIB 3: sta. DW18, 23°42′S, 167°59′E, 338 m, 1sh; sta. DW9, 24°42′S, 168°08′E, 265 m, 1sh; sta. DW 17, 23°41′S 167°10′E, 238 m, 1 sh - SMIB 4: sta. DW44, 24°46′S, 168°08′E, 270–300 m, 2 sh; sta. DW46, 24°47′S, 168°09′E, 245–260 m, 1 sh – SMIB 5: sta. DW70, 23°41′S, 168°01E, 270 m, 1 sh; sta. DW71, 23°41′S, 168°01′E, 265 m, 1 sh – SMIB 8: sta. DW154, 24°45′S, 168°08′E, 235–252 m, 1 sh; sta. DW155, 24°45.7′S, 168°08.2′E, 257–262 m, 2 shs; sta. DW157, 24°46′S, 168°08′E, 251–255 m, 2 shs; sta. DW158, 24°46.1′S, 168°02.2′E, 262–290 m, 3 shs; sta. DW159, 24°46′S, 168°08′E, 241–245 m, 2 shs; sta. DW163, 24°49.1′S, 168°08.9′E, 310–460 m, 1 spms + 3 shs + 1 juv. coated; sta. DW165, 24°47.6′S, 168°09.6′E, 372–660 m, 3 shs; sta. DW181, 23°17.7′S, 168°04.8′E, 311–330 m, 1 spm - SMIB 10: sta. DW209, 24°49′S, 168°09′E, 329–560 m, 1 sh – BERYX 11: sta. DW 40, 23°41′ S, 168°01′ E, 240–300 m, 1 sh – CHALCAL 2: sta. 2 CP21, 24°54′S, 168°22′E, 500 m, 1 sh; sta. DW71, 24°42′S, 168°10′E, 230 m, 3 sh; sta. DW81, 23°20′S, 168°03′E, 311 m, 1 sh; sta. CP20, 24°45′S, 168°09′E, 230 m, 1 spm. + 1 sh coated – LITHIST: sta. DW11, 24°46.7′S, 168°08.3′E, 254–283 m, 2 shs; sta. DW12, 24°45.7′S, 168°08.1′E, 235–280 m, 1 sh. Ride des Loyaute, SMIB 5: sta. DW88, 22°19′S, 168°40′E, 350 m, 1 sh; sta DW91, 22°18′S, 168°41′E, 340 m, 1 sh; sta. DW93, 22°20′S, 168°42′E, 255 m, 1 sh – MUSORSTOM 6: sta. DW482, 21°21′S, 167°47′E, 375 m, 2 sh; sta. DW478, 21°09′S, 167°54′E, 400 m, 1 sh Coral Sea, MUSORSTOM 5: Banc Argo, sta. 299, 22°48′S, 159°24′E, 360–390 m, 1 sh. See Richer de Forges (1990, 1993) and Richer de Forges & Chevillon (1996) for details on the sampling area and the relevant stations.



**Figs 4-9** *Babelomurex neocaledonicus* n. sp.: **4**, **5** paratype (SMIB 8, sta. DW 157), 24°46′S, 168°08′E, 235-300 m. **6**, **7** paratype (SMIB 8, sta. DW 163), 24°50′S, 168°09′E, 310-460 m. **8**, **9** paratype (SMIB 8, sta. DW 184), 23°18′S, 168°05′E, 305-320 m. Scale bars = 10 mm.



**Figs 10-13** *Babelomurex neocaledonicus* n. sp. **10** Coral Sea (MUSORSTOM 5: Banc Argo, sta. 299), 22°48′S, 159°24′E, 360-390 m. **11** (CHALCAL 2: sta. CP20), 24°45′S, 168°09′E, 230 m. **12, 13** paratype (SMIB 8: sta. DW 181), 23°17.7′S, 168°04.8′E, 311-330 m. Scale bars = 100 µm (**10, 11**) and 10 mm (**12, 13**).

*Type locality* 23°41′S, 168°01′E, 245–260 m, South of New Caledonia, South West Pacific.

*Description* Shell light, of medium size for the genus, with a height of 25–31 mm in the largest adults (26.8 mm in the holotype). Protoconch of 3.5 whorls, with slightly convex sides. Protoconch-I of 0.8 whorls, sculptured with pustules all over the surface. Protoconch-II of 2.7 whorls, sculptured by three series of vertical threads that tend to fuse, giving rise to collabral ribs on the last protoconch whorl. Suprasutural series usually placed over a keel of the whorl. A second keel appears on the second protoconch whorl, in correspondence of the intermediate keel.

Teleoconch of 5 to 6 (5 in the holotype) whorls in the largest shells. Spire low, broadly conical, with straight or slightly convex sides, sharply angulated at the shoulder, with broad, triangular spines. Last whorl convex below the shoulder, gently angulated at the periphery, with well constricted base. Aperture large, subquadrangular. Outer lip incised in correspondence with the spines. Inner lip reflected, covering the columellar area. Umbilicus open. Siphonal canal long, straight or slightly bent, open. Sculpture on the first teleoconch whorls consisting of a major row of spines on the shoulder, and 12–14 spiral cords on the last whorl (shoulder and convex part of whorl) crossed by finely imbricated lamellae. Some of these cords become stronger on the periphery of the last whorls with the scaly projections becoming spines. Larger adult specimens with two or three series of these triangular spines at the periphery of the body whorl: one major row at angulation and one or two weaker ones below the angulation. Spines consisting of folded laminae, with the narrow open side toward the aperture. Teleoconch microsculpture of very minute spiral threads and irregular growth lines. The threads become less visible below the shoulder where the irregular growth lines become more evident and acquire a scaly appearance.

Shell ivory white, with pink bands extending from the subsutural area to the row of spines at the periphery. Each band corresponds to a spine, and the spines are pink at least on the tip.

Operculum semicircular with terminal nucleus, brownish.

*Derivation of name* The epithet *neocaledonicus* refers to the region of the South West Pacific (New Caledonia) to which pertains the type locality.

*Remarks* The combination of shell shape, sculpture and coloration of *B. neocaledonicus* is unique. The subquadrangular shape of the teleoconch whorls is somehow comparable with *Hirtomurex winckworthi* (Fulton, 1930), that has a different pattern of ornamentation with numerous spiral cords and axial lamellae, with much less prominent spines on the shoulder, and with a colour uniformly white-yellowish (see Kosuge & Suzuki, 1985: pl. 22, figs. 1–4).

The triangular narrow spines and the pink coloration are common in the *Babelomurex spinosus* (Hirase, 1908) species group, but all these species have a higher spire and a smaller size.

There is some resemblance with the species of the *B. deburghiae* (Reeve, 1857) group, that differ in having constantly the inner lip simple (not reflected to cover the columella) and lacking the spiny secondary keels below the shoulder.

Finally, some specimens of *B. purpuratus* (Chenu, 1859) are very similar to *B. neocaledonicus* n. sp. The main differences are in the colour pattern, the more scabrous sculpture and higher spire of the new species.

The new species has been collected so far only in a restricted area in the south-west Pacific. It is not known from the intensively explored Philippines, nor has it been found during the MUSORSTOM campaigns to Vanuatu and Fiji.

## ACKNOWLEDGEMENTS

We wish to thank Philippe Bouchet who allowed us to revise the coralliophiline material from the French expeditions to SW Pacific. Philippe Maestrati is thanked for his skilful co-operation with sorting the samples. Benoit Fontaine (MNHN, Paris) is thanked for assistance with light photographs. A PARSYST visit grant to MO allowed the junior author to stay at the MNHN. Virginie Heros is heartily thanked for her assistance during the stay and her cooperation with managing samples.

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# ANNOTATED CHECKLIST OF THE NON-MARINE MOLLUSCS OF MOUNT KENYA, KENYA

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*Abstract* *This paper presents an annotated checklist of the non-marine molluscs of Mount Kenya, based on species records in the literature, museum collections and the results of a National Museums of Kenya Darwin Initiative field study of the molluscs of the forest zone in 1996/97. The checklist is divided into 3 parts. The first contains a total of 111 species (104 terrestrial and 7 freshwater) which have well-authenticated records for Mt Kenya. The second list contains 17 species (15 terrestrial and 2 freshwater) that may occur on Mt Kenya since they have been reported from the central Kenyan highlands generally. The third list consists of 7 terrestrial species that have been reported from Mt Kenya but which are probably errors. The paper also presents a brief assessment of the biogeographical and ecological affinities of the Mt Kenya mollusc fauna, and of the species that appear to be endemic on the mountain.*

*Key words* *Mount Kenya, Mollusca, non-marine, Kenya, forests*

## INTRODUCTION

Mount Kenya is the second highest mountain in Africa (5199 m) and forms an isolated conical massif with a basal diameter of about 120 km in central Kenya, about 180 km north of Nairobi on the east side of the great Rift Valley just south of equator. A belt of forest encircles the mountain in a band which currently extends from about 1800 m to 2800 m altitude. The area of the forest is 228,340 ha (2283 km$^2$) (KIFCON, 1994). Climatic factors define the upper tree limit, but forest clearance has substantially raised the lower limit of forest and most of the lower parts of the mountain which formerly supported forest are now either under cultivation or have been planted with mostly exotic fast-growing softwoods. Above the tree line the vegetation consists of heathland, afro-alpine vegetation and semi-desert.

Work on molluscs from Mt Kenya began late in the 19th century, when Smith (1894) described two species (*Zingis gregorii* and *Vitrina baringoensis)* collected by Gregory, a scientist who made the first collections of land-snails from Mt Kenya. At the beginning of the 20th century, Hugh Preston (1911) described thirty six species of mollusc from Mount Kenya. He did not collect this material himself, but identified and catalogued material sent to him by Robin Kemp, a collector of small birds and mammals who was paid to collect material in East Africa, C.W. Woodhouse (believed to be a game warden) and A. Blayney Percival. Matthew Connolly worked on material given to him by Hugh Preston and several species, especially in the family Streptaxidae, were described from Mount Kenya and the surrounding area in his 1922 paper. Both Preston and Connolly published other species descriptions from Mt Kenya and references to these can be found in Adam (1971). By 1928, there had been a period of malacological exploration of the other East African mountains, enabling Germain (1931) to write a comparative account of the molluscan fauna of the high peaks. In this paper he listed 44 species from Mt Kenya, although he also indicated that he was not confident that some of the records were accurate. The most recent and prolific work on East African molluscs is by the botanist Bernard Verdcourt. In the late 1950's and 1960's he was based in the East African Herbarium, then part of the East African Agriculture and Forestry Research organisation in Nairobi, and he travelled extensively around Kenya and Tanzania. Using this opportunity he collected, and subsequently wrote numerous papers on, terrestrial

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molluscs, as well as building the collections which are now present in the National Museums of Kenya. Realising the problems facing all research workers on the East African mollusc fauna, he compiled *A Preliminary Checklist of East African Non-Marine Molluscs* which was published in 1983. Seventy four species are listed for Mt Kenya in this checklist, which was compiled using his own papers and unpublished data, as well as earlier literature. Martin Pickford (1995), who was based at the National Museums of Kenya for a time, also presented a list of 45 species, of which 4 were not identified, for Mount Kenya in his review of the fossil land-snail fauna of East Africa of which 17 species were from the Castle Rest House Station; most of Pickford's material is lodged in the NMK. Other authors have provided little detailed locality information about species; none is given in Germain (1931), and little provided in Verdcourt (1983), Preston (1911) or Connolly (1922). Other malacologists have collected from Mt Kenya, and their collections were used by Verdcourt for his research. Åke Holm and Åke Anderson made extensive collections from Mt Kenya, as well as Mt Kilimanjaro and Mt Meru in Tanzania (collections in Stockholm Museum). Malcolm Coe made an expedition to Mt Kenya during the International Geophysical year, and his new molluscan records were published as part of a monograph (Coe, 1967). Large collections of material can also be found in the collections of Royal Institute of Natural Sciences in Brussels, and these have been used in revisionary work on the family Streptaxidae of east and central Africa undertaken by van Goethem and Adam.

Germain (1931) observed that Mt Kenya's mollusc fauna was distinct, being dominated by species of small sizes, while the largest are in the achatinid genera *Limicolaria* and *Limicolariopsis*. He noted the ability of the stenogyrids (including the subulinids) (which are characteristically inhabitants of hot, tropical regions), to live between 2000–3300 m. In addition he reported that the genera *Limicolariopsis* and *Bocageia* were endemic in E. African mountains and were confined to Mts Meru, Kenya, Kilimanjaro, Ruwenzori and Aberdare ranges.

## THE CHECKLIST

This paper presents an up-dated and annotated list of the molluscs of Mount Kenya. The opportunity to update the list arises from a NMK/Darwin Initiative survey of the molluscs of the forest regions of Mt Kenya (Warui, 1998). The fieldwork took place in 1996/1997, and since then the samples have been processed and analysed. The objective of the study was to explore the faunas in forest communities at different elevations along the Chogoria, Sirimon, Naro Moru and Kamweti routes which are broadly orientated on the east, north-west, west and south sides of the mountain respectively (Figure 1).

In addition to providing a list of species, the paper presents preliminary observations on the distributions of the species on the mountain and their ecologies, based on the surveys carried out in 1996/97. It is hoped that such information will encourage further investigations on the mollusc fauna of the mountain. A more detailed and thorough analysis of the ecology of the molluscan communities, which includes details of the methods and results of the 1996/97 survey, is under preparation (Tattersfield, Warui, Seddon & Kiringe, in review).

### IDENTIFICATION AND ANALYSIS

Mollusc specimens collected during the current survey have been named, as far as possible, by reference to the literature and using museum collections in National Museums of Kenya (NMK), National Museum of Wales (Cardiff, UK) and Natural History Museum (London). However, the taxonomy and delineation of many East African

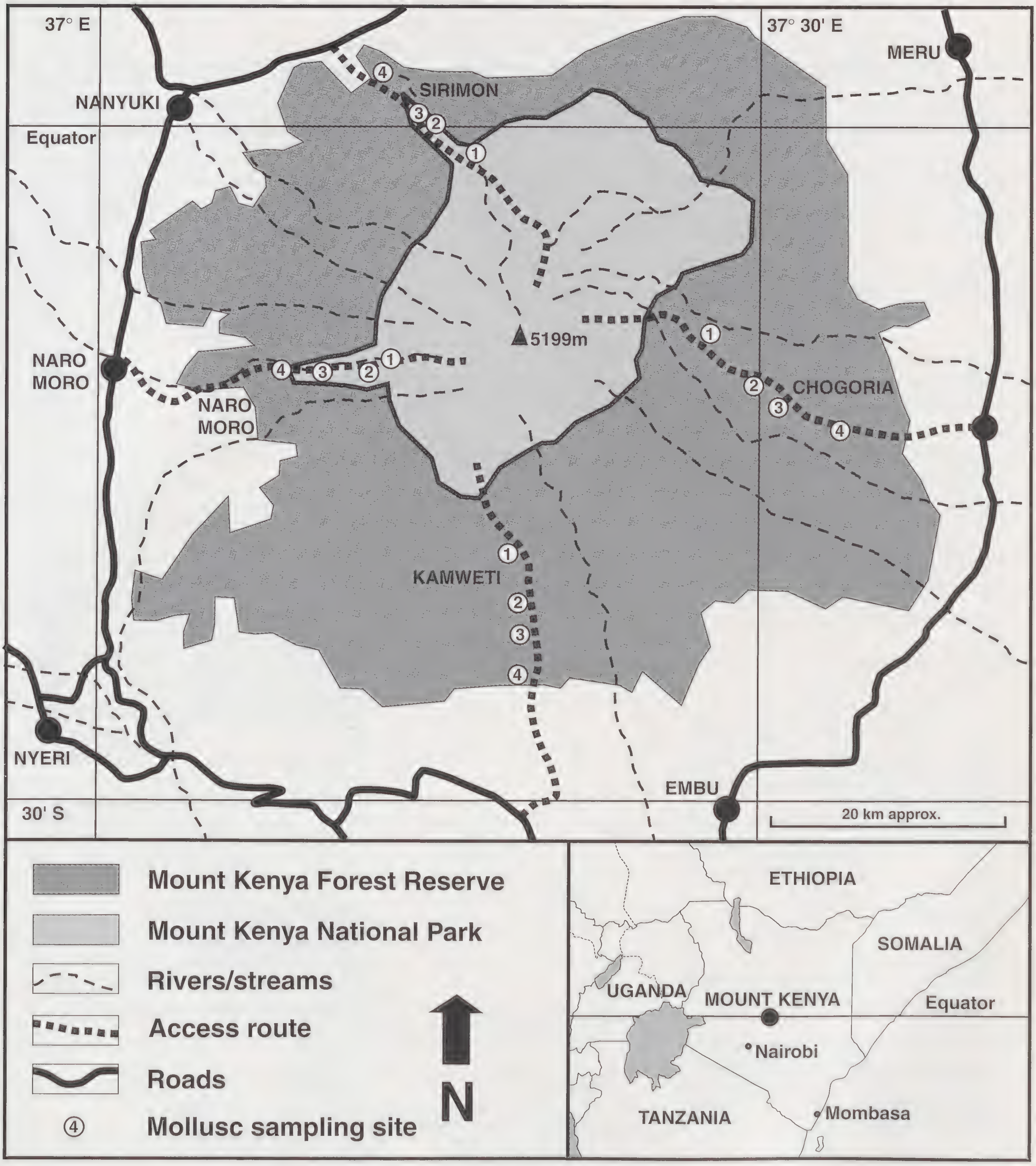

**Figure 1** Map of Mount Kenya

terrestrial mollusc species is still in a confused and dynamic state. Inadequate descriptions, imprecise locality information and a widespread absence of anatomical information further hinder identification. Some notes on identification are also provided for species that have been recorded from the mountain for the first time during the 1996/97 surveys.

Three lists of Mount Kenya molluscs are presented here. The first, (Table 1) contains 111 species and subspecies - 104 terrestrial and 7 freshwater taxa - for which there are well-authenticated records for Mount Kenya. These generally are derived from Verdcourt's (1983) *Checklist* or from the our surveys undertaken in 1996/97. Other records come from literature published since 1983, identification of material in museum

## TABLE 1
## Checklist of Mollusca from Mount Kenya

| SPECIES | SYNONYMS | SOURCE | | | | ENDEMIC | DISTRIBUTION (based on current study) | NOTES (identification notes from current study and other additional information ) |
|---|---|---|---|---|---|---|---|---|
| | | V | G | P | CS | | | |
| **GASTROPODA** | | | | | | | | |
| **PROSOBRANCHIA** | | | | | | | | |
| **Hydrocenidae** | | | | | | | | |
| *Hydrocena kenyana* Connolly, 1929 | | + | | | + | E | Mid-high altitude; Naro Moro route only | Given in Verdcourt (1983) as *Hydrocena kenyense* in error. |
| **Cyclophoridae** | | | | | | | | |
| *Elgonocyclus koptawelilensis* (Germain, 1934) | | | | | + | | | Compared with material (NMK) from Mount Elgon (type locality) |
| **Maizaniidae** | | | | | | | | |
| *Maizania volkensii* (von Martens, 1895) | *pyramidalis* (K.L. Pfeiffer, 1952) | | | | + | | Widespread (current study) | Mt. Kenya material matches *volkensii* from Shume, Tanzania (NMK). Types of *marsabitensis* (NMK) have less elevated spire and larger umbilicus. |
| **PULMONATA** | | | | | | | | |
| **Planorbidae** | | | | | | | | |
| *Bulinus cf. tropicus* (Krauss, 1848) | *B. rumrutiensis* (Preston, 1913). | | | | | | | Material in BM collections from Lake Ellis (BMNH.1952.4.22.9.16) Coll. by a Game Warden in July 1939). Verdcourt (pers. comm, 2001 comments that it appears to be a ribbed form similar to one from Mt Elgon, and may be related to Ethiopian forms). |
| **Vertiginidae** | | | | | | | | |
| *Lauria desiderata* (Preston, 1911) | *alluaudi* Germain, 1934 | + | + | + | + | | Abundant and more or less confined to mid-high altitudes; Naro Moro and Sirimon routes only | Originally described from Mt Kenya, from an altitude of 9000 - 10,000 feet (Preston, 1911) |
| *Negulus kenianus* (Preston, 1912) | | + | + | + | + | | Low to mid altitudes; widespread but not recorded on Sirimon route | |
| *Truncatellina arboricola* Tattersfield, 1996 | | | | | + | | | |
| *Truncatellina pygmaeorum* (Pilsbry & Cockerell, 1933) | *Franzia sinistrorsa* Blume, 1965 | + | | | + | | High altitude - 88% of specimens found above 2606m; Naro Moro and Sirimon routes only | |
| *Truncatellina* sp A. | | | | | + | | Mid to high altitudes; Naro Moro and Sirimon routes | |
| **Valloniidae** | | | | | | | | |
| *Acanthinula expatriata* Preston, 1911 | | + | + | | + | | A high altitude species (>90% of specimens above 2369m) most frequent on Naro Moru and Sirimon routes | |
| *Pupisoma harpula* (Reinhardt, 1886) | | | | | + | | Low to mid altitudes; widespread but not recorded on Sirimon route | Smaller and more conical than other spp (det. Tattersfield). |
| *Pupisoma orcula* (Benson, 1850) | | | | | + | | Widespread in forest zone | |
| *Pupisoma renschi* K.L. Pfeiffer, 1952 | | + | | + | + | | Apparently confined to mid-elevation forests between 2163-2605m. Most abundant on Naro Moro route and not recorded on Chogoria or Kamweti routes | Material in NMK collection - Mt Kenya, 12,500 feet leg. Verdcourt. |
| *Pupisoma* sp. A (listed by Warui, 1998) | | | | | + | | Rare | Smooth shell, large deep umbilicus, faint spiral microsculpture on apex, oblique rather irregular but close and not strong radial ribs; c.D=2.1mm, H=1.5mm. Possibly new. |
| *Pupisoma* sp. B (listed by Warui, 1998) | | | | | + | | Rare on Naro Moro route | Similar shape but slightly less elevated than *orcula* . A few triangular spines and traces of lamellae; umbilicus open and deep; apex with granular (not spiral) microsculpture. Similar to *Acanthinula sp. B* from Site 2A Kakamega (Tattersfied 1996) but Kakamega specimen has closed umbilicus. Possibly new. |
| **Enidae** | | | | | | | | |
| *Cerastua roosevelti* (Dall, 1910) | *nobilis* Preston, 1911 | + | + | + | | E | | 2000-2700m (Germain). Paratypes in NMK. |
| *Edouardia turricula* (Preston, 1911) | | + | | | + | | | |
| *Rhachidina chiradzuluensis* var. *virginea* (Preston, 1911) | | + | | | + | | Rare | Highlands (Verdcourt 1983). NW. Mt Kenya at Mrimba Forest (Verdcourt & Polhill). |
| **Clausiliidae** | | | | | | | | |
| *Macroptychia degeneris* (Preston, 1911) | | + | | + | | | | |
| **Subulinidae** | | | | | | | | |
| *Curvella deliciosa* Preston, 1911 | | + | + | + | + | | Most common at high altitudes (>2606m); not recorded on Sirimon route | |
| *Curvella* sp. Listed in Verdcourt (1983) as near *elgonensis* Connolly, | | | | | + | | | Material labelled *C. elgonensis* from Mt Kenya, Castle Rest House leg. M Pickford matches material from current study.Material from Entebbe and Kakamega (NMK) has stronger ribbing but are good match for general shape and size. |
| *Euonyma* sp. juveniles *(cf. topazon* Connolly, 1923*)* | | | | | | | | Verdcourt (pers. comm, 2001) notes that he identified material collected by Holm (Stockholm 172 & 173) as *Euonyma* , a new record from Mt Kenya. |
| *Krapfiella mirabilis* Preston, 1911 | | + | + | + | | | | 6000-8000 feet (Preston); material in NMK - Sagana River 6400' |
| *Nothapalus dohertyi* (E.A. Smith, 1903) | | + | + | + | + | | Abundant at low altitudes in Naro Moro and Kamweti; rare elsewhere | NMK material - Nyambeni Hills leg. Hemming & Verdcourt (1960) |
| *Nothapalus iredalei* (Preston, 1911) | | + | + | | | | | 2000-2700m (Germain) |
| *Nothapalus suturalis* Preston, 1911 | | + | + | | + | E | Low to high altitudes; most common on Kamweti and Chogoria routes | NMK material - Bamboo-Heather Zone, Castle Rest Houseleg. Pickford |
| *Opeas aphantum* Connolly, 1923 | | + | + | + | | E | | |
| *Oreohomorus* sp.Listed in Verdcourt, 1983 as nr. *nitidus* (von Martens) | | + | | | + | | A species closely matching *nitidus* was recorded from low to mid altitudes on Kamweti and Chogoria routes in current study. | At least 2 species close to *nitidus* have been reported from Mt. Kenya (Pickford 1995; Verdcourt 1983) - Marimba NE slopes, bamboo-heather Zone, Castle Rest House; Thiba River, 2085m |
| *Pseudoglessula (Kempiconcha) transenna* Connolly, 1923 | | + | | + | | E | | Forests N.of Mt. Kenya (Connolly) |
| *Pseudopeas orestias* (Preston, 1911) | | + | + | + | | | | 9000-10000 feet (Preston) |
| *Pseudopeas* sp. A (as listed in Warui, 1998) | | | | | + | | Low to mid altitudes; widespread | This species does not match NMK material of any other *Pseudopeas* species listed for Mt. Kenya in Verdcourt (1983). |
| *Pseudopeas* sp. B (as listed in Warui, 1998) | | | | | + | | Widespread. | Material from current study does not match either *rumrutiense* or *orestias* , which are the only 2 species of *Pseudopeas* reported in Verdcourt (1983). |
| *Subuliniscus adjacens* Connolly, 1923 | | | | | + | | Uncommon on Naro Moro and Sirimon routes. Verdcourt (1998) reports from this species under wood on Sirimon track, 2700m | |
| *Subulona egregia* Preston, 1911 | | + | + | | + | | Low to mid-altitudes, not recorded on Sirimon and Naro Moro routes | NMK material - Thiba River Forest, 6400 feet, Mt. Kenya, leg.Copley. |
| *Subulona rex* (Preston, 1913) | | + | + | + | | E | | |
| **Achatinidae** | | | | | | | | |
| *Limicolariopsis inepta* (Preston, 1911) | | + | + | + | + | | Uncommon at mid-altitude forest; widespread | |
| *Limicolariopsis keniana* E.A. Smith, 1903 | | + | + | | + | | Low to mid-altitudes, most frequent on Naro Moro and Kamweti routes | |
| *Limicolariopsis laevis* Crowley & Pain, 1961 | | + | | + | | E | | |
| *Limicolariopsis perobtusa* (Preston, 1912) | | + | | | | | | |
| *Limicolariopsis verdcourti* Crowley & Pain, 1961 | | + | | | + | E | Uncommon on Naro Moro route | |
| **Endodontidae** | | | | | | | | |
| *Punctum ugandanum* (E.A. Smith, 1903) | | | | | + | | Naro Moro | |
| *Punctum* sp. C (listed by Warui, 1998) | | | | | + | | Widespread | |

TABLE 1 (continued)

| SPECIES | SYNONYMS | SOURCE | | | | ENDEMIC | DISTRIBUTION (based on current study) | NOTES (identification notes from current study and other additional information ) |
|---|---|---|---|---|---|---|---|---|
| | | V | G | P | CS | | | |
| *Punctum* sp. (listed by Verdcourt, 1983 as *P. cf. pallidum* (Connolly, 1922) | | + | | + | + | | Low to mid altitude; widespread but most common on Naro Moro and Sirimon routes. | Verdcourt (1991) notes that *pallidum* has not been confirmed from East Africa. Verdcourt (1983) - Upper Kerita West Valley, 3750m in festuca tussocks leg. Harmsen & Jabbie. Material at MCA, Tervuren Museum |
| *Punctum* sp. D (listed by Warui, 1998) | | | | | + | | Mid altitudes on the Naro Moro route | |
| *Trachycystis ariel* Preston, 1910 | | + | | | + | | Widespread but apparently uncommon | NMK material - Mrima Hill, Mt Kenya, leg. Verdcourt 1957 |
| *Trachycystis iredalei* Preston, 1912 | *T. bernardinae* Connolly, 1925 | + | | | + | | Not recorded in high altitude forests; widespread | |
| *Trachycystis lamellifera* (E.A.Smith,1903) | *T. rugosa* Preston, 1911 | + | | | + | | Mid-high altitude forests; Naro Moro and Sirimon routes only | |
| **Vitrinidae** | | | | | | | | |
| *Vitrina nigrocincta* von Martens, 1897 | | +? | | + | | | | Verdcourt (1983) tentatively lists this species from Mt. Kenya, to 3000m. Pickford (1995) reports it from Castle Rest House Station. Verdcourt (pers. comm.) noted the species was found under *Sedum* on rocks at 3840 m(BV) and under logs and on *Lobelia keniensis* at 3300m (IGY expedition) |
| Vitrina sp. | | + | | | | E | | Verdcourt (1983) lists 3 un-named, high altitude species: Deep olive-green shell, intense black animal; Lewis Glacier moraine, 4400m |
| Vitrina sp. | | + | | | | E | | Similar but not equal to olive green species, 10x8x5mm; Mackinder valley, 3150m. |
| Vitrina sp. | | + | | | | E | | Similar to other unnamed species from Mackinder valley but pale and smaller initial whorls; Mackinder valley, 3150m. |
| *Vitrina lactea* Connolly, 1925 | | + | + | + | + | Near E | | 2550-3750m (Verdcourt). Verdcourt (pers. comm.) noted the species was found above Naro Moru on dead *Lobelia* leaves at 2800m (IGY expedition) |
| **Helicarionidae** | | | | | | | | |
| *Kaliella barrakporensis* (Pfeiffer, 1852) | *consobrina* Preston, 1912;<br>*kigeziensis* Preston, 1912 | + | | | + | | c.95% of specimens below 2368m; widespread | NMK material - Mrima Hill, leg. Verdcourt 1957 |
| *Kaliella iredalei* Preston, 1912 | | + | | | + | | Low to high altitudes; widespread but perhaps commonest on Naro Moro and Sirimon routes | |
| **Euconulidae** | | | | | | | | |
| *Afroconulus diaphanus* (Connolly, 1922) | | + | | + | | | | |
| *Afroconulus iredalei* (Preston, 1910) | | | | | + | | Most frequent at low altitudes; widespread | NMK material - Marimba, NW. Mt. Kenya, leg. Verdcourt & Polhill, 1960 |
| *Afroguppya quadriscupta* (Connolly, 1939) | | | | | + | | Low to mid-altitudes; widespread but not recorded on Sirimon route | |
| *Afroguppya rumurutiensis* (Preston, 1911) | *opposita* Preston, 1912 | | | | + | | Uncommon low to high altitudes; Naro Moro and Kamweti routes | |
| **Urocyclidae** | | | | | | | | |
| *Africarion orestias* Preston, 1914 | | + | + | + | | E | | Slopes of Mount Kenya (Preston) |
| *Bukobia signata* (Pollonera, 1911) | | + | | + | | E | | Mt. Kenya, montane forest 9-10,000 feet. Coll. R. Kemp (Verdcourt, 1960) |
| *Chlamydarion* sp. | | | | | | | | Verdcourt (pers. comm, 2001) notes that he identified material collected by Holm (Stockholm 172 , 176, 188,189) from Rogati Forest at 2000 m ASL as *Chlamydarion* sp., a new record from Mt Kenya. |
| *Helicarion aethodus* Connolly, 1925 | | + | + | + | | E | | |
| *Atoxon hildebrandti* | | | | | | | | Verdcourt (pers. comm., 2001) notes that Van Goethem records this species on Mt Kenya. |
| *Trichotoxon heynmanni* Simroth, 1889 | *keniensis* Pollonera, 1911;<br>*keniaensis* Germain, 1920 ;<br>*nyambense violaceus* Verdcourt & Polhill, 1960 | | + | | | | | 3000-3300m (Germain). *nyambense violaceus* - at 7,500 feet near Marimba, NW. Mt. Kenya, leg. Verdcourt & Polhill, 1960. |
| *Trochonanina crassiplicata* (Preston, 1914) | | | | + | | | | Forests N.of Mt. Kenya |
| *Trochonanina keniana* (Preston, 1911) | | + | | + | | | 6000-8000 feet, Naro Moro track 8500 feet | |
| *Trochonanina levistriata* (Preston, 1913 ) | | + | | + | | | | Between Mt K and Euasso Nyiro. NMK material - bamboo Forest, 10,000 feet, leg. Verdcourt 1957 |
| *Trochozonites medjensis* Pilsbry, 1919 | | | | +? | + | | Rare, Low to mid altitude; Chogoria and Kamweti routes only. All specimens collected have shell apex removed. | |
| *Trochozonites* sp. A (listed by Warui, 1998) | | | | | + | | Rare | First 0.5 whorl pitted, remaining 1.5 apical whorls with closer, strong regular ribs, rest of shell with strong, slightly curved, oblique ribs, locally variable in strength and spacing. Shell outline concave. No spiral element visible in sculpture. Base of shell smooth. Shell of largest specimen c.5.5mm x 5mm. Probably an undescribed *Trochozonites* sub-genus *Teleozonites*. |
| *'Vitrina' baringoensis* Smith, 1894 | | + | | | + | | A species tentatively identified as '*Vitrina* ' *baringoensis* was found to be widespread during the current study, especially at higher altitudes. This species is not a member of genus *Vitrina* , although as it is listed in Verdcourt, 1983 as that taxon, it has also been listed here as '*Vitrina* '. | Verdcourt places this 'problem' species in the Urocyclidae. |
| **Bradybaenidae** | | | | | | | | |
| *Halolimnohelix cf. iredalei* (Connolly, 1925 ) | | | | | + | | Most frequent at high altitudes but extending down to <2162m; widespread. Only poor, dead material was collected. | Verdcourt (1973) lists *iredalei* from Solai <Mt Kenya> leg. R. Kemp (2100-2700m) but notes that this probably refers to Solai above Nakuru. Not listed in Verdcourt (1983). Material from current study is close to *iredalei* (NMK material). Material examined by Verdcourt at MRAC from Mt Kenya also matches this species (Verdcourt, 1969) |
| *Halolimnohelix consanguinea* (Preston, 1911) | | + | + | + | | E | | 2000-2300m (Germain) |
| *Halolimnohelix ? plana* | | | | | | | Verdcourt (pers, comm. 2001) identified Holm material from Rogati Forest, as possibly this taxon. | |
| *Halolimnohelix planulata* (Preston, 1911) | | + | | | + | E | Extends to >2606m but most frequent at low altitudes; widespread. | |
| *Halolimnohelix* sp. | | + | | | | | | An undescribed species tentatively assigned to *Halolimnohelix* (Verdcourt, 1983). |
| *Haplohelix* sp. | | | | + | | | | Pickford (1995) - Castle Rest House Station |
| *Vicariihelix mukulensis* (Pilsbry, 1919) | | | | | + | | Extends to >2606m but most frequent at low altitudes; not recorded on Sirimon route. | Listed for Kenya highlands by Verdcourt (1983). Verdcourt (pers. comm, 2001) notes that he determined material collected by Holm as this species from Naru Moru track in the *Hagenia* - *Hyperium* zone at 3130m ASL. |
| *Vicariihelix gregorii* (E.A.Smith, 1894) | | + | + | | + | | | Bottom of forest zone (Germain). NMK material - Mt. Kenya 10,000 feet leg. Verdcourt. |

TABLE 1 (continued)

| SPECIES | SYNONYMS | SOURCE | | | | ENDEMIC | DISTRIBUTION (based on current study) | NOTES (Identification notes from current study and other additional information ) | |
|---|---|---|---|---|---|---|---|---|---|
| | | V | G | P | CS | | | | |
| *Vicariihelix kenianus alticola* Verdcourt, 1974 | | + | | | | E | | NMK material - paratypes from Teleki Tarn Mt. Kenya 14,000feet, leg. M.Coe. Stockholm: Holm Collection 350, 4200m in Teleki Valley at Mackinders Camp (det B. Verdcourt, pers. comm. 2001) | |
| *Vicariihelix kenianus depressa* Verdcourt. 1974 | | + | | | | E | | Teleki Valley, 12,800 feet leg. M. Coe. | |
| *Vicariihelix kenianus kenianus* Verdcourt, 1974 | | + | | + | | E | | Verdcourt (1974) recorded this species from the Sirimon track in the *Hagenia- Podocarpus* forest under mossy logs from 9000' to 13,000 feet. | |
| *Vicariihelix* sp. | | + | | | | | | Undescribed species (Verdcourt 1983). | |
| *Vicariihelix* sp. | | + | | | | Near E | | Undescribed (Mount Kenya, Meru). | |
| **Streptaxidae** | | | | | | | | | |
| *Gonaxis innocens* (Preston, 1910) | | + | | + | + | | Low to High altitudes on Kamweti and Chogoria routes | NMK material - Sagana River 6400 feet. | |
| *Gulella columella* (E.A.Smith, 1903) | | | | | + | | Mid altitudes on the Naro Moro and Sirimon routes | Matches material in NMK from Kenya bamboo forest, Uplands, leg & det. Verdcourt. | |
| *Gulella hector* (Preston, 1913) | | + | | | | | | | |
| *Gulella insolita* (Smith, 1903) | *keniana* ( Preston, 1911); *Gulella franzi* Blume, 1965 | + | | | + | | Low to high altitudes; widespread | | |
| *Gulella ugandensis* (Smith, 1901) | *G. optata* (Preston, 1911), moloensis Adam, 1965 | + | + | | | | | Germain noted this species was found between 2000 2300m (as *G. optata* ). Verdcourt & Polhill records this species from Marimba Forest. | |
| *Gulella pervitrea* (Preston, 1913) | | + | | + | + | | Low altitude (<2162m) on Chogoria route | Verdcourt & Polhill records this species from Marimba Forest. | |
| *Gulella pilula* (Preston, 1911) | incl. *jombeneensis* ( Preston, 1913) | + | | + | + | | Low altitude (<2162m) on Chogoria and Kamweti routes | NMK material - Castle Hill Resthouse, leg. Pickford. | |
| *Gulella pretiosa pretiosa* (Preston, 1911) | | + | + | | + | | Below 2162m on Chogoria and Kamweti routes | | |
| *Gulella princei* (Preston, 1911) | | + | | + | + | Near E | | Mount Kenya; Aberdares. Mt. Kenya material matches princei material in NMK collected from Aberdares (det Verdcourt). | |
| *Gulella prodigiosa* (E.A.Smith, 1903) | | + | | + | | | | NMK material - Sagana River 6400 feet. | |
| *Gulella cf. sellae* Pollonera, 1906 | | | | + | | | | | |
| *Gulella simplicima* (Preston, 1911) | | + | | + | + | | Mid-high altitude; widespread but most common on Naro and Sirimon routes | | |
| *Gulella syngenes* (Preston, 1913) | *consobrina* Preston, 1911 | + | | + | | E | | | |
| *Ptychotrema uniliratum* (E. A. Smith, 1903) | | + | | | + | | 88% of specimens found above 2369m; widespread but not recorded on Sirimon route | Verdcourt & Polhill records this species from Marimba Forest. | |
| *Stenomarconia jeanneli* (Germain, 1934) | | + | | + | + | E | | Verdcourt (pers. comm. 2001) notes that this species was orginally described from 3 localities: 3300-3700m, 4000m and 3650m. Van Goethem's Mt Kenya Bio Expedition also collected this species on the Sirimon Track at 3600m, 3365m and 3220m ASL and at Liki Nord, Ontulili River 4000m. | |
| *Streptostele crassicrenulata* Connolly, 1922 | | + | + | | + | | Widespread in current study. | Forests N of Mount Kenya (Connolly, 1922b); highlands to 3000m (Verdcourt, 1983). | |
| *Streptostele exasperata* (Preston, 1912) | probably = *crassiplicata* Connolly, 1922 | + | + | + | + | | Widespread but most common on Naro Moro and Sirimon routes. | 2000-3000m (Germain) | |
| *Streptostele iota* Connolly, 1922 | | + | + | + | | | | 2200-3000m (Germain) | |
| *Streptostele kenyana* Connolly, 1922 | | + | + | + | | E | | 2400-2700m (Germain); 2400m (Verdcourt) | |
| *Streptostele* sp. C (listed by Warui, 1998) | | | | | + | | Low to mid altitudes; commonest on Chogoria route | Sp. C does not match any *Streptostele* spp. in Verdcourt (1983). | |
| *Tayloria* sp. close to *marsabitensis* (Preston, 1913) | | | | | + | | Low to mid altitudes on Chogoria route | Close to material named cf. *marsabitensis* from Nyambeni leg. Verdcourt. | |
| *Streptostele angustior* (Preston, 1911) | probably = *terebra* ( Preston, 1911) | | | + | | | | Rumuruti to Mt Kenya (Preston); Pickford (1995) reports from Castle Forest Rest House | |
| **BIVALVIA** | | | | | | | | | |
| **Sphaeriidae** | | | | | | | | | |
| *Pisidium armillatum* Kuiper, 1966 | *P. kigeziense* var.*rugosiuscula* (ex Preston) in Kuiper, 1966. | + | | | | | | | |
| *Pisidium artifex* Kuiper, 1960 | | + | | | | | | Hall Tarns, 4300m | |
| *Pisidium casertanum* (Poli, 1791) | | | | | | | | Verdcourt (in litt. 2000) notes the presence of this taxon on Mt Kenya. | |
| *Pisidium kenianum* (Preston, 1911) | *katangense* (Pilsbry & Bequaert, 1927), *P. kigeziense*, Mandahl-Barth 1954; *P. woodwardianum* (ex Preston), Kuiper, 1966 | + | + | | | | | Preston (1911) notes specimens from 9000-10000 feet. | Check this as Daget (1998) lists species type locality as between Rumruti & Mt Kenya |
| *Pisidium montigenum* Kuiper, 1966 | | + | | | | | | Tarns to 4500m. Type locality Lac Hohnel, Mt Kenya. | |
| *Pisidium ovampicum* Ancey, 1890 | *P.georgeanum* Kuiper, 1952; *S. masakaense* (ex Preston) Kuiper, 1966. | | | | | | | Kuiper, 1966 lists four lots from Mt Kenya in collections from 2900 to 4400 m (Verdcourt, 2001 pers. comm) | |
| Key: | | | | | | | | | |
| V - Verdcourt (1983) | | | | | | | | | |
| G - Germain (1928) | | | | | | | | | |
| P - Pickford (1995) | | | | | | | | | |
| CS - Current Study | | | | | | | | | |
| E - Endemic | | | | | | | | | |

collections at National Museums of Kenya, National Museum of Wales, Natural History Museum (London), Stockholm Museum (Holm Collection, determinations by Bernard Verdcourt including additional taxa from Mt Kenya: see notes in Table 1) and Royal Institute for Natural Sciences, Brussels (IRSNB; dets. B. Verdcourt). The second list (Table 2) consists of 17 species – 15 terrestrial and 2 freshwater species - that have been reported generally from the central highlands of Kenya. We consider it reasonable to assume that these species may be present on Mount Kenya, although we have not located any specific records for them from the mountain; these records were obtained from Verdcourt (1983). Table 1 therefore contains the most conservative list of species from Mount Kenya, whereas Table 2 consists of additional species that are considered likely to occur, based on their general distribution in Kenya and ecology. There may be additional species present on Mount Kenya with wider distributions in East Africa, which are not identified on this Table 2. Table 3 contains 7 terrestrial species that that have been previously reported from Mount Kenya, but which we have rejected for inclusion in the checklist, mainly because of ecological or biogeographical reasons; further details are provided in Table 3.

Where available or appropriate, the following information is provided for each species in Tables 1 and 2:

- The source(s) of the records (records from the 1996/7 survey are referred to as the current study).
- Distributional and ecological observations based mainly on the current study, including species which appear to be endemic to Mount Kenya.
- Details of identification for new species records added during the current study.

## ENDEMICITY, BIOGEOGRAPHICAL AND ECOLOGICAL RELATIONS OF THE FAUNA

An analysis of Table 1 allows a preliminary assessment of the levels of endemicity and the ecological and biogeographical relations of the fauna; a fuller analysis will be given in Tattersfield *et al.* (in review).

Twenty two taxa (22% of the fauna on Table 1) have only been reported from Mount Kenya and are thus apparently endemic to the mountain; these include 3 high altitude species in the family Vitrinidae which have not yet been formally described. A further 3 species can be considered near-endemics, having only been reported from Mt Kenya and other close by areas, such as the Aberdares. Five (23%) of the endemic taxa were recorded during the current survey. The remaining species are more widely distributed, from the Kenyan central highlands generally, across East Africa or more widely. The Mt Kenya molluscan fauna as recognised in Table 1, constitutes about 19.5% of the known Kenya fauna of 514 species (Seddon *et al.*, 1996).

Sixty two species and sub-species were recorded in the forests habitats during the current study, only 12 less than were listed for the whole mountain (ie. including moorland and afro-alpine habitats) by Verdcourt (1983). The current study has added up to 20 species to the known fauna of Mt Kenya as assessed from previously published information. These include 8 mostly small species, which have, as yet, either not been identified or have not been formally described. They also include several named minute species such as *Elgonocyclus koptawelilensis* and *Punctum ugandanum,* and widespread species (e.g. *Maizania volkensii, Afroguppya quadrisculpta)* that do not appear to have been specifically listed for Mt Kenya before.

The current survey indicated that some species are strongly associated with forest of a particular aspect. Seven species *(Punctum sp.* D, *Hydrocena kenyana, Limicolariopsis verdcourti, Pupisoma sp.* B, *Edouardia turricula, Elgonocyclus koptawelilensis* and *Subuliniscus adjacens)* were only found on the west-facing Naro Moru transect, while *Gulella pervitrea, Rhachidina chiradzuluensis* and *Oreohomorus cf nitidus* were only recorded along the Chogoria Route which faces east. No species were exclusively restricted to the Kamweti or Sirimon Routes. However, some species showed clear associations with either the south- and east-facing Kamweti and Chogoria routes, or the west and northwest facing Naro Moru and Sirimon routes. Eight out of the 67 species recorded during the survey were restricted to one of these pairs of routes. This indicates that the forest mollusc faunas along the Naro Moru and Sirimon routes are similar, but that they differ from the fauna in the forests on the Kamweti and Chogoria routes.

TABLE 2

Species listed in Verdcourt (1983) for central Kenya highlands, but not specifically from Mt Kenya

| SPECIES | SYNONYMS | NOTES |
|---|---|---|
| *Nesopupa bisulcata* (Jickeli, 1912) | *iota* Preston, 1911 | Records poorly localised |
| *Pupilla ?duplicata* (Preston, 1911) | | Mount Kenya to Rumuruti |
| *Lymnaea truncatula* (Muller, 1774) | *mweruensis* Connolly, 1929 | Highlands; Mweru, N. of Mt. Kenya |
| *Burnupia crassistriata* (Preston, 1911) | | Verdcourt (pers. comm. 2001) notes that the species is found in the Rivers near Meru (near Kiongo, River Mariara at 2000 m ASL. Leg. M. Samsoen, Van Goethem's Expedition material). Verdcourt (1983) Highlands; between Mt. Kenya and Rumuruti (Preston) |
| *Cerastua bambuseti bambuseti* (von Martens) | | Highlands (Varied) |
| *Euonyma topazon topazon* Connolly, 1923 | | Highlands |
| *Pseudopeas rumurutiense* (Preston, 1911) | *pollux* Preston ms name | W & C Highlands |
| *Trachycystis abbysinica* (Jickeli, 1874) | *approximans* Preston, 1911;<br>*imitata* Smith, 1903;<br>*pseudocharopa* Preston, 1911 | Records poorly localised |
| *Vitrina ugandensis* Thiele, 1911 (chck) | | Highlands 1500-3000m |
| *Thapsia nemorum* (Preston, 1914) | | Central Highlands |
| *Trochonanina densestriata* Thiele, 1911 | | Highlands |
| *Gonaxis elgonensis* (Preston, 1913) | | Highlands |
| *Gulella aberdarensis* (Preston, 1913) | probably = *insolita* Smith 1903 | Highlands |
| *Gulella commoda* (E.A. Smith, 1903) | | Highlands |
| *Gulella dartevellei* Verdcourt | | Highlands |
| *Gulella duncani* Connolly, 1930 | | Highlands |
| *Streptostele lenta* E.A. Smith, 1903 | | Highlands |

NOTE: Other species not restricted to the highland areas of Kenya may occur on Mount Kenya.

TABLE 3

Unauthenticated records which have not been accepted for the Mt Kenya checklist

| SPECIES | SYNONYMS | SOURCE | | NOTES |
|---|---|---|---|---|
| | | G | P | |
| *Rhachistia rhodotaenia* (von Martens, 1869) | *rorkorensis* Kobelt | + | | A species of dry, scrub areas, and near the coast. |
| *Subuliniscus cornu-orycis* Connolly, 1923 | | + | | Reported from Mt. Nyiro, northern Kenya. |
| *Limicolariopsis elgonensis* Crowley & Pain, 1961 | | | + | A western Kenyan species - Mt Elgon etc. |
| *Limicolariopsis dimidiata* (von Martens, 1890) | | | | Not listed at all in Verdcourt 1983. Verdcourt (pers comm. 2001) comments that this species was described as *Limicolaria flammea* var *dimidiata* and raised to species level by von Martens in 1897. The type locality was Mt Kilimanjaro. He suggests that it is a form of *Limicolaria martensiana* and that the species could occur around the base of Mt Kenya. |
| *Trochonanina mozambicensis* (Pfeiffer, 1855) | | + | | A dry-land species unlikely on Mt. Kenya. |
| *Gonaxis kibweziensis* (E.A. Smith, 1894) | | + | | A species of dry, scrub areas. Near the coast and Taita. |
| *Ptychotrema cedrorum* (Connolly, 1922) | | + | | A western Kenyan species - Mt Elgon etc. |

KEY:

G - Germain (1928)
P - Pickford (1995)

The endemic species are of greatest nature conservation interest, especially those that are restricted to lower altitude forests, which have suffered the greatest reduction. Of the 5 endemic species recorded during the current survey, 2, namely *Limicolariopsis verdcourti* and *Hydrocena kenyana* were completely restricted to the Naro Moru route. More than 50% of the specimens of *Halolimnohelix planulata* collected were found on the in Kamweti route , the remainder being distributed across the other 3 transects. *Nothapalus suturalis* was found on all of the transects, but was commonest on the Kamweti and Chogoria routes.

This preliminary analysis of the checklist and current survey data has shown the mollusc fauna of Mount Kenya holds significant nature conservation interest. It supports approximately one fifth of the country's mollusc fauna and several range-restricted, endemic species. Such a conclusion supports the work of other biologists and conservationists (Bussman 1994, Lockwood 1995) who have emphasised the need to reduce and ideally halt further loss of forest habitats (Kenya Wildlife Service 1999) in order to conserve the important reservoir of biodiversity on Mount Kenya.

More work needs to be done to explore the mollusc fauna in the regions above the forest zone, and also to document the conservation status of other soil invertebrate groups that have not yet been studied (Warui 1998).

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| SPECIES | SYNONYMS | SOURCE | | | | E |
|---|---|---|---|---|---|---|
| | | V | G | P | CS | |
| **Urocyclidae** | | | | | | |
| *Africarion orestias* Preston, 1914 | | + | + | + | | |
| *Bukobia signata* (Pollonera, 1911) | | + | | + | | |
| *Chlamydarion* sp. | | | | | | |
| *Helicarion aethodus* Connolly, 1925 | | + | + | + | | |
| *Atoxon hildebrandti* | | | | | | |
| *Trichotoxon heynmanni* Simroth, 1889 | *keniensis* Pollonera, 1911; *keniaensis* Germain, 1920 ; *nyambense violaceus* Verdcourt & Polhill, 1960 | | + | | | |
| *Trochonanina crassiplicata* (Preston, 1914) | | | | + | | |
| *Trochonanina keniana* (Preston, 1911) | | + | | + | | |
| *Trochonanina levistriata* (Preston, 1913 ) | | + | | + | | |
| *Trochozonites medjensis* Pilsbry, 1919 | | | | +? | + | |
| *Trochozonites* sp. A (listed by Warui, 1998) | | | | | + | |
| *Vitrina' baringoensis* Smith, 1894 | | + | | | + | |
| **Bradybaenidae** | | | | | | |
| *Halolimnohelix cf. iredalei* (Connolly, 1925 ) | | | | | + | |
| *Halolimnohelix consanguinea* (Preston, 1911) | | + | + | + | | |
| *Halolimnohelix ? plana* | | | | | | |
| *Halolimnohelix planulata* (Preston, 1911) | | + | | | + | |
| *Halolimnohelix* sp. | | + | | | | |
| *Haplohelix* sp. | | | | + | | |
| *Vicariihelix mukulensis* (Pilsbry, 1919) | | | | | + | |
| *Vicariihelix gregorii* (E.A.Smith, 1894) | | + | + | | + | |
| *Vicariihelix kenianus alticola* Verdcourt, 1974 | | + | | | | |
| *Vicariihelix kenianus depressa* Verdcourt, 1974 | | + | | | | |
| *Vicariihelix kenianus kenianus* Verdcourt, 1974 | | + | | + | | |
| *Vicariihelix* sp. | | + | | | | |
| *Vicariihelix* sp. | | + | | | | |
| **Streptaxidae** | | | | | | |
| *Gonaxis innocens* (Preston, 1910) | | + | | + | + | |
| *Gulella columella* (E.A.Smith, 1903) | | | | | + | |
| *Gulella hector* (Preston, 1913) | | + | | | | |
| *Gulella insolita* (Smith, 1903) | *keniana* ( Preston, 1911); *Gulella franzi* Blume, 1965 | + | | | + | |
| *Gulella ugandensis* (Smith, 1901) | *G. optata* (Preston, 1911), moloensis Adam, | + | + | | | |

| SPECIES | SYNONYMS | SOURCE | | | | ENDEMIC | DISTRIBUTION (based on current study) | NOTES (identification notes from current study and other additional information) |
|---|---|---|---|---|---|---|---|---|
| | | **V** | **G** | **P** | **CS** | | | |
| **GASTROPODA** | | | | | | | | |
| **PROSOBRANCHIA** | | | | | | | | |
| **Hydrocenidae** | | | | | | | | |
| *Hydrocena kenyenana* Connolly, 1929 | | + | | | + | E | Mid-high altitude; Naro Moro route only | Given in Verdcourt (1983) as *Hydrocena kenyense* in error. |
| **Cyclophoridae** | | | | | | | | |
| *Elgonocyclus koptawelilensis* (Germain, 1934) | | | | | + | | | Compared with material (NMK) from Mount Elgon (type locality) |
| **Maizaniidae** | | | | | | | | |
| *Maizania volkensii* (von Martens, 1895) | *pyramidalis* (K.L. Pfeiffer, 1952) | | | | + | | Widespread (current study) | Mt. Kenya material matches *volkensii* from Shume, Tanzania (NMK). Types of *marsabitensis* (NMK) have less elevated spire and larger umbilicus. |
| **PULMONATA** | | | | | | | | |
| **Planorbidae** | | | | | | | | |
| *Bulinus cf. tropicus* (Krauss, 1848) | *B. rumrutiensis* (Preston, 1913). | | | | | | | Material in BM collections from Lake Ellis (BMNH.1952.4.22.9.16) Coll. by a Game Warden in July 1939). Verdcourt (pers. comm, 2001 comments that it appears to be a ribbed form similar to one from Mt Elgon, and may be related to Ethiopian forms). |
| | | | | | | | | |
| **Vertiginidae** | | | | | | | | |
| *Lauria desiderata* (Preston, 1911) | *alluaudi* Germain, 1934 | + | + | + | + | | Abundant and more or less confined to mid-high altitudes; Naro Moro and Sirimon routes only | Originally described from Mt Kenya, from an altitude of 9000 - 10,000 feet (Preston, 1911) |
| *Negulus kenianus* (Preston, 1912) | | + | + | + | + | | Low to mid altitudes; widespread but not recorded on Sirimon route | |
| *Truncatellina arboricola* Tattersfield, 1996 | | | | | + | | | |
| *Truncatellina pygmaeorum* (Pilsbry & Cockerell, 1933) | *Franzia sinistrorsa* Blume, 1965 | + | | | + | | High altitude - 88% of specimens found above 2606m; Naro Moro and Sirimon routes only | |
| *Truncatellina* sp A. | | | | | + | | Mid to high altitudes; Naro Moro and Sirimon routes | |
| **Valloniidae** | | | | | | | | |
| *Acanthinula expatriata* Preston, 1911 | | + | + | | + | | A high altitude species (>90% of specimens above 2369m) most frequent on Naro Moru and Sirimon routes | |
| *Pupisoma harpula* (Reinhardt, 1886) | | | | | + | | Low to mid altitudes; widespread but not recorded on Sirimon route | Smaller and more conical than other spp (det. Tattersfield). |
| *Pupisoma orcula* (Benson, 1850) | | | | | + | | Widespread in forest zone | |
| *Pupisoma renschi* K.L. Pfeiffer, 1952 | | + | | + | + | | Apparently confined to mid-elevation forests between 2163-2605m. Most abundant on Naro Moro route and not recorded | Material in NMK collection - Mt Kenya, 12,500 feet leg. Verdcourt. |
| *Pupisoma* sp. A (listed by Warui, 1998) | | | | | + | | Rare | Smooth shell, large deep umbilicus, faint spiral microsculpture on apex, oblique rather irregular but close and not strong radial ribs; c.D=2.1mm, H=1.5mm. Possibly new. |
| *Pupisoma* sp. B (listed by Warui, 1998) | | | | | + | | Rare on Naro Moro route | Similar shape but slightly less elevated than *orcula* . A few triangular spines and traces of lamellae; umbilicus open and deep; apex with granular (not spiral) microsculpture. Similar to *Acanthinula sp. B* from Site 2A Kakamega (Tattersfied 1996) but Kakamega specimen has closed umbilicus. Possibly new. |
| **Enidae** | | | | | | | | |
| *Cerastua roosevelti* (Dall, 1910) | *nobilis* Preston, 1911 | + | + | + | | E | | 2000-2700m (Germain). Paratypes in NMK. |
| *Edouardia turricula* (Preston, 1911) | | + | | | + | | | |
| *Rhachidina chiradzuluensis* var. *virginea* (Preston, 1911) | | + | | | + | | Rare | Highlands (Verdcourt 1983). NW. Mt Kenya at Mrimba Forest (Verdcourt & Polhill). |
| **Clausiliidae** | | | | | | | | |
| *Macroptychia degeneris* (Preston, 1911) | | + | | + | | | | |
| **Subulinidae** | | | | | | | | |
| *Curvella deliciosa* Preston, 1911 | | + | + | + | + | | Most common at high altitudes (>2606m); not recorded on Sirimon route | |
| *Curvella* sp. Listed in Verdcourt (1983) as near *elgonensis* Connolly, | | | | | + | | | Material labelled *C. elgonensis* from Mt Kenya, Castle Rest House leg. M Pickford matches material from current study.Material from Entebbe and Kakamega (NMK) has stronger ribbing but are good match for general shape and size. |
| *Euonyma* sp. juveniles *(cf. topazon* Connolly, 1923*)* | | | | | | | | Verdcourt (pers. comm, 2001) notes that he identified material collected by Holm (Stockholm 172 & 173) as *Euonyma* , a new record from Mt Kenya. |
| *Krapfiella mirabilis* Preston, 1911 | | + | + | + | | | | 6000-8000 feet (Preston); material in NMK - Sagana River 6400’ |
| *Nothapalus dohertyi* (E.A. Smith, 1903) | | + | + | + | + | | Abundant at low altitudes in Naro Moro and Kamweti; rare elsewhere | NMK material - Nyambeni Hills leg. Hemming & Verdcourt (1960) |
| *Nothapalus iredalei* (Preston, 1911) | | + | + | | | | | 2000-2700m (Germain) |
| *Nothapalus suturalis* Preston, 1911 | | + | + | | + | E | Low to high altitudes; most common on Kamweti and Chogoria routes | NMK material - Bamboo-Heather Zone, Castle Rest Houseleg. Pickford |
| *Opeas aphantum* Connolly, 1923 | | + | + | + | | E | | |
| *Oreohomorus* sp.Listed in Verdcourt, 1983 as nr. *nitidus* (von Martens) | | + | | | + | | A species closely matching *nitidus* was recorded from low to mid altitudes on Kamweti and Chogoria routes in current study. | At least 2 species close to *nitidus* have been reported from Mt. Kenya (Pickford 1995; Verdcourt 1983) - Marimba NE slopes, bamboo-heather Zone, Castle Rest House; Thiba River, 2085m |
| *Pseudoglessula (Kempiconcha) transenna* Connolly, 1923 | | + | | + | | E | | Forests N.of Mt. Kenya (Connolly) |
| *Pseudopeas orestias* (Preston, 1911) | | + | + | + | | | | 9000-10000 feet (Preston) |
| *Pseudopeas* sp. A (as listed in Warui, 1998) | | | | | + | | Low to mid altitudes; widespread | This species does not match NMK material of any other *Pseudopeas* species listed for Mt. Kenya in Verdcourt (1983). |
| *Pseudopeas* sp. B (as listed in Warui, 1998) | | | | | + | | Widespread. | Material from current study does not match either *rumrutiense* or *orestias* , which are the only 2 species of *Pseudopeas* reported in Verdcourt (1983). |
| *Subuliniscus adjacens* Connolly, 1923 | | | | | + | | Uncommon on Naro Moro and Sirimon routes. Verdcourt (1998) reports from this species under wood on Sirimon track, 2700m | |
| *Subulona egregia* Preston, 1911 | | + | + | | + | | Low to mid-altitudes, not recorded on Sirimon and Naro Moro routes | NMK material - Thiba River Forest, 6400 feet, Mt. Kenya, leg.Copley. |
| *Subulona rex* (Preston, 1913) | | + | + | + | | E | | |
| **Achatinidae** | | | | | | | | |
| *Limicolariopsis inepta* (Preston, 1911) | | + | + | + | + | | Uncommon at mid-altitude forest; widespread | |
| *Limicolariopsis keniana* E.A. Smith, 1903 | | + | + | | + | | Low to mid-altitudes, most frequent on Naro Moro and Kamweti routes | |
| *Limicolariopsis laevis* Crowley & Pain, 1961 | | + | | + | | E | | |
| *Limicolariopsis perobtusa* (Preston, 1912) | | + | | | | | | |
| *Limicolariopsis verdcourti* Crowley & Pain, 1961 | | + | | | + | E | Uncommon on Naro Moro route | |
| **Endodontidae** | | | | | | | | |
| *Punctum ugandanum* (E.A. Smith, 1903) | | | | | + | | Naro Moro | |
| *Punctum* sp. C (listed by Warui, 1998) | | | | | + | | Widespread | |
| *Punctum* sp. (listed by Verdcourt, 1983 as *P. cf. pallidum* (Connolly, 1922) | | + | | + | + | | Low to mid altitude; widespread but most common on Naro Moro and Sirimon routes. | Verdcourt (1991) notes that *pallidum* has not been confirmed from East Africa. Verdcourt (1983) - Upper Kerita West Valley, 3750m in festuca tussocks leg. Harmsen & Jabbie. Material at MCA, Tervuren Museum |
| *Punctum* sp. D (listed by Warui, 1998) | | | | | + | | Mid altitudes on the Naro Moro route | |
| *Trachycystis ariel* Preston, 1910 | | + | | | + | | Widespread but apparently uncommon | NMK material - Mrima Hill, Mt Kenya, leg. Verdcourt 1957 |
| *Trachycystis iredalei* Preston, 1912 | *T. bernardinae* Connolly, 1925 | + | | | + | | Not recorded in high altitude forests; widespread | |
| *Trachycystis lamellifera* (E.A.Smith,1903) | *T. rugosa* Preston, 1911 | + | | | + | | Mid-high altitude forests; Naro Moro and Sirimon routes only | |
| **Vitrinidae** | | | | | | | | |
| *Vitrina nigrocincta* von Martens, 1897 | | +? | | + | | | | Verdcourt (1983) tentatively lists this species from Mt. Kenya, to 3000m. Pickford (1995) reports it from Castle Rest House Station. Verdcourt (pers. comm.) noted the species was found under *Sedum* on rocks at 3840 m(BV) and under logs and on *Lobelia keniensis* at 3300m (IGY expedition) |
| Vitrina sp. | | + | | | | E | | Verdcourt (1983) lists 3 un-named, high altitude species: Deep olive-green shell, intense black animal; Lewis Glacier moraine, 4400m |
| Vitrina sp. | | + | | | | E | | Similar but not equal to olive green species, 10x8x5mm; Mackinder valley, 3150m. |
| Vitrina sp. | | + | | | | E | | Similar to other unnamed species from Mackinder valley but pale and smaller initial whorls; Mackinder valley, 3150m. |
| *Vitrina lactea* Connolly, 1925 | | + | + | + | + | Near E | | 2550-3750m (Verdcourt). Verdcourt (pers. comm.) noted the species was found above Naro Moru on dead *Lobelia* leaves at 3300m (IGY expedition) |
| **Helicarionidae** | | | | | | | | |
| *Kaliella barrakporensis* (Pfeiffer, 1852) | *consobrina* Preston, 1912; *kigeziensis* Preston, 1912 | + | | | + | | c.95% of specimens below 2368m; widespread | NMK material - Mrima Hill, leg. Verdcourt 1957 |
| *Kaliella iredalei* Preston, 1912 | | + | | | + | | Low to high altitudes; widespread but perhaps commonest on Naro Moro and Sirimon routes | |
| **Euconulidae** | | | | | | | | |
| *Afroconulus diaphanus* (Connolly, 1922) | | + | | + | | | | |
| *Afroconulus iredalei* (Preston, 1910) | | | | | + | | Most frequent at low altitudes; widespread | NMK material - Marimba, NW. Mt. Kenya, leg. Verdcourt & Polhill, 1960 |
| *Afroguppya quadriscupta* (Connolly, 1939) | | | | | + | | Low to mid-altitudes; widespread but not recorded on Sirimon route | |
| *Afroguppya rumurutiensis* (Preston, 1911) | *opposita* Preston, 1912 | | | | + | | Uncommon low to high altitudes; Naro Moro and Kamweti routes | |

| SPECIES | SYNONYMS | SOURCE | | | | ENDEMIC | DISTRIBUTION (based on current study) | NOTES (identification notes from current study and other additional information) |
|---|---|---|---|---|---|---|---|---|
| | | V | G | P | CS | | | |
| **Urocyclidae** | | | | | | | | |
| *Africarion orestias* Preston, 1914 | | + | + | + | | E | | Slopes of Mount Kenya (Preston) |
| *Bukobia signata* (Pollonera, 1911) | | + | | + | | E | | Mt. Kenya, montane forest 9-10,000 feet. Coll. R. Kemp (Verdcourt, 1960) |
| *Chlamydarion* sp. | | | | | | | | Verdcourt (pers. comm, 2001) notes that he identified material collected by Holm (Stockholm 172 , 176, 188,189) from Rogati Forest at 2000 m ASL as *Chlamydarion* sp., a new record from Mt Kenya. |
| *Helicarion aethodus* Connolly, 1925 | | + | + | + | | E | | |
| *Atoxon hildebrandti* | | | | | | | | Verdcourt (pers. comm., 2001) notes that Van Goethem records this species on Mt Kenya. |
| *Trichotoxon heynmanni* Simroth, 1889 | *keniensis* Pollonera, 1911; *keniaensis* Germain, 1920 ; *nyambense violaceus* Verdcourt & Polhill, 1960 | | + | | | | | 3000-3300m (Germain). *nyambense violaceus* - at 7,500 feet near Marimba, NW. Mt. Kenya, leg. Verdcourt & Polhill, 1960. |
| *Trochonanina crassiplicata* (Preston, 1914) | | | | + | | | | Forests N.of Mt. Kenya |
| *Trochonanina keniana* (Preston, 1911) | | + | | + | | | 6000-8000 feet, Naro Moro track 8500 feet | |
| *Trochonanina levistriata* (Preston, 1913 ) | | + | | + | | | | Between Mt K and Euasso Nyiro. NMK material - bamboo Forest, 10,000 feet, leg. Verdcourt 1957 |
| *Trochozonites medjensis* Pilsbry, 1919 | | | | +? | + | | Rare, Low to mid altitude; Chogoria and Kamweti routes only. All specimens collected have shell apex removed. | |
| *Trochozonites* sp. A (listed by Warui, 1998) | | | | | + | | Rare | First 0.5 whorl pitted, remaining 1.5 apical whorls with closer, strong regular ribs, rest of shell with strong, slightly curved, oblique ribs, locally variable in strength and spacing. Shell outline concave. No spiral element visible in sculpture. Base of shell smooth. Shell of largest specimen c.5.5mm x 5mm. Probably an undescribed *Trochozonites* sub-genus *Teleozonites.* |
| *Vitrina' baringoensis* Smith, 1894 | | + | | | + | | A species tentatively identified as *'Vitrina' baringoensis* was found to be widespread during the current study, especially at higher altitudes. This species is not a member of genus *Vitrina*, although as it is listed in Verdcourt, 1983 as that taxon, it has also been listed here as *'Vitrina'*. | Verdcourt places this 'problem' species in the Urocyclidae. |
| **Bradybaenidae** | | | | | | | | |
| *Halolimnohelix cf. iredalei* (Connolly, 1925 ) | | | | | + | | Most frequent at high altitudes but extending down to <2162m; widespread. Only poor, dead material was collected. | Verdcourt (1973) lists *iredalei* from Solai <Mt Kenya> leg. R. Kemp (2100-2700m) but notes that this probably refers to Solai above Nakuru. Not listed in Verdcourt (1983). Material from current study is close to *iredalei* (NMK material). Material examined by Verdcourt at MRAC from Mt Kenya also matches this species (Verdcourt, 1969) |
| *Halolimnohelix consanguinea* (Preston, 1911) | | + | + | + | | E | | 2000-2300m (Germain) |
| *Halolimnohelix ? plana* | | | | | | | Verdcourt (pers, comm. 2001) identified Holm material from Rogati Forest, as possibly this taxon. | |
| *Halolimnohelix planulata* (Preston, 1911) | | + | | | + | E | Extends to >2606m but most frequent at low altitudes; widespread. | |
| *Halolimnohelix* sp. | | + | | | | | | An undescribed species tentatively assigned to *Halolimnohelix* (Verdcourt, 1983). |
| *Haplohelix* sp. | | | | + | | | | Pickford (1995) - Castle Rest House Station |
| *Vicariihelix mukulensis* (Pilsbry, 1919) | | | | | + | | Extends to >2606m but most frequent at low altitudes; not recorded on Sirimon route. | Listed for Kenya highlands by Verdcourt (1983) |
| *Vicariihelix gregorii* (E.A.Smith, 1894) | | + | + | | + | | | Bottom of forest zone (Germain). NMK material - Mt. Kenya 10,000 feet leg. Verdcourt. |
| *Vicariihelix kenianus alticola* Verdcourt, 1974 | | + | | | | E | | NMK material - paratypes from Teleki Tarn Mt. Kenya 14,000feet, leg. M.Coe. |
| *Vicariihelix kenianus depressa* Verdcourt, 1974 | | + | | | | E | | Teleki Valley, 12,800 feet leg. M. Coe. |
| *Vicariihelix kenianus kenianus* Verdcourt, 1974 | | + | | + | | E | | Verdcourt (1974) recorded this species from the Sirimon track in the *Hagenia- Podocarpus* forest under mossy logs from 9000' to 13,000 feet. |
| *Vicariihelix* sp. | | + | | | | | | Undescribed species (Verdcourt 1983). |
| *Vicariihelix* sp. | | + | | | | Near E | | Undescribed (Mount Kenya, Meru). |
| **Streptaxidae** | | | | | | | | |
| *Gonaxis innocens* (Preston, 1910) | | + | | + | + | | Low to High altitudes on Kamweti and Chogoria routes | NMK material - Sagana River 6400 feet. |
| *Gulella columella* (E.A.Smith, 1903) | | | | | + | | Mid altitudes on the Naro Moro and Sirimon routes | Matches material in NMK from Kenya bamboo forest, Uplands, leg & det. Verdcourt. |
| *Gulella hector* (Preston, 1913) | | + | | | | | | |
| *Gulella insolita* (Smith, 1903) | *keniana* ( Preston, 1911); *Gulella franzi* Blume, 1965 | + | | | + | | Low to high altitudes; widespread | |
| *Gulella ugandensis* (Smith, 1901) | *G. optata* (Preston, 1911), moloensis Adam, 1965 | + | + | | | | | Germain noted this species was found between 2000-2300m (as *G. optata* ). Verdcourt & Polhill) records this species from Marimba Forest. |
| *Gulella pervitrea* (Preston, 1913) | | + | | + | + | | Low altitude (<2162m) on Chogoria route | Verdcourt & Polhill record this species from Marimba Forest. |
| *Gulella pilula* (Preston, 1911) | incl. *jombeneensis* ( Preston, 1913) | + | | + | + | | Low altitude (<2162m) on Chogoria and Kamweti routes | NMK material - Castle Hill Resthouse, leg. Pickford. |
| *Gulella pretiosa pretiosa* (Preston, 1911) | | + | + | | + | | Below 2162m on Chogoria and Kamweti routes | |
| *Gulella princei* (Preston, 1911) | | + | | + | + | Near E | | Mount Kenya; Aberdares. Mt. Kenya material matches princei material in NMK collected from Aberdares (det Verdcourt). |
| *Gulella prodigiosa* (E.A.Smith, 1903) | | + | | + | | | | NMK material - Sagana River 6400 feet. |
| *Gulella cf. sellae* Pollonera, 1906 | | | | + | | | | |
| *Gulella simplicima* (Preston, 1911) | | + | | + | + | | Mid-high altitude; widespread but most common on Naro and Sirimon routes | |
| *Gulella syngenes* (Preston, 1913) | *consobrina* Preston, 1911 | + | | + | | E | | |
| *Ptychotrema uniliratum* (E. A. Smith, 1903) | | + | | | + | | 88% of specimens found above 2369m; widespread but not recorded on Sirimon route | Verdcourt & Polhill record this species from Marimba Forest. |
| *Stenomarconia jeanneli* (Germain, 1934) | | + | | + | + | E | | |
| *Streptostele crassicrenulata* Connolly, 1922 | | + | + | | + | | Widespread in current study. | Forests N of Mount Kenya (Connolly, 1922b); highlands to 3000m (Verdcourt, 1983). |
| *Streptostele exasperata* (Preston, 1912) | probably = *crassiplicata* Connolly, 1922 | + | + | + | + | | Widespread but most common on Naro Moro and Sirimon routes. | 2000-3000m (Germain) |
| *Streptostele iota* Connolly, 1922 | | + | + | + | | | | 2200-3000m (Germain) |
| *Streptostele kenyana* Connolly, 1922 | | + | + | + | | E | | 2400-2700m (Germain); 2400m (Verdcourt) |
| *Streptostele* sp. C (listed by Warui, 1998) | | | | | + | | Low to mid altitudes; commonest on Chogoria route | Sp. C does not match any Streptostele spp. in Verdcourt (1983). |
| *Tayloria* sp. close to *marsabitensis* (Preston, 1913) | | | | | + | | Low to mid altitudes on Chogoria route | Close to material named cf. marsabitensis from Nyambeni leg. Verdcourt. |
| *Streptostele angustior* (Preston, 1911) | probably = *terebra* ( Preston, 1911) | | | + | | | | Rumuruti to Mt Kenya (Preston); Pickford (1995) reports from Castle Forest Rest House |
| **BIVALVIA** | | | | | | | | |
| **Sphaeriidae** | | | | | | | | |
| *Pisidium armillatum* Kuiper, 1966 | P. *kigeziense* var.*rugosiscula* (ex Preston) in Kuiper, 1966. | + | | | | | | |
| *Pisidium artifex* Kuiper, 1960 | | + | | | | | | Hall Tarns, 4300m |
| *Pisidium casertanum* (Poli, 1791) | | | | | | | | Verdcourt (in litt. 2000) notes the presence of this taxon on Mt Kenya. |
| *Pisidium kenianum* (Preston, 1911) | *katangense* (Pilsbry & Bequaert, 1927), *P. kigeziense,* Mandahl-Barth 1954; *P. woodwardianum* (ex Preston), Kuiper, 1966 | + | + | | | | | Preston (1911) notes specimens from 9000-10000 feet. |
| *Pisidium montigenum Kuiper, 1966* | | + | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| *Pisidium montigenum* Kuiper, 1966 | | + | | | | | | Tarns to 4500m. Type locality Lac Hohnel, Mt Kenya. |
| *Pisidium ovampicum* Ancey, 1890 | *P.georgeanum* Kuiper, 1952; *S. masakaense* (ex Preston) Kuiper, 1966. | | | | | | | Kuiper, 1966 lists four lots from Mt Kenya in collections from 2900 to 4400 m (Verdcourt, 2001 pers. comm) |
| | | | | | | | | |
| **Key:** | | | | | | | | |
| | | | | | | | | |
| V - Verdcourt (1983) | | | | | | | | |
| G - Germain (1928) | | | | | | | | |
| P - Pickford (1995) | | | | | | | | |
| CS - Current Study | | | | | | | | |
| E - Endemic | | | | | | | | |

| NDEMIC | DISTRIBUTION (based on current study) | NOTES (identification notes from current study and other additional information) |
|---|---|---|
| | | |
| | | |
| E | | Slopes of Mount Kenya (Preston) |
| E | | Mt. Kenya, montane forest 9-10,000 feet. Coll. R. Kemp (Verdcourt, 1960) |
| | | Verdcourt (pers. comm, 2001) notes that he identified material collected by Holm (Stockholm 172 , 176, 188,189) from Rogati Forest at 2000 m ASL as *Chlamydarion* sp., a new record from Mt Kenya. |
| E | | |
| | | Verdcourt (pers. comm., 2001) notes that Van Goethem records this species on Mt Kenya. |
| | | 3000-3300m (Germain). *nyambense violaceus* - at 7,500 feet near Marimba, NW. Mt. Kenya, leg. Verdcourt & Polhill, 1960. |
| | | Forests N.of Mt. Kenya |
| | 6000-8000 feet, Naro Moro track 8500 feet | |
| | | Between Mt K and Euasso Nyiro. NMK material - bamboo Forest, 10,000 feet, leg. Verdcourt 1957 |
| | Rare, Low to mid altitude; Chogoria and Kamweti routes only. All specimens collected have shell apex removed. | |
| | Rare | First 0.5 whorl pitted, remaining 1.5 apical whorls with closer, strong regular ribs, rest of shell with strong, slightly curved, oblique ribs, locally variable in strength and spacing. Shell outline concave. No spiral element visible in sculpture. Base of shell smooth. Shell of largest specimen c.5.5mm x 5mm. Probably an undescribed *Trochozonites* sub-genus *Teleozonites.* |
| | A species tentatively identified as *'Vitrina' baringoensis* was found to be widespread during the current study, especially at higher altitudes. This species is not a member of genus *Vitrina*, although as it is listed in Verdcourt, 1983 as that taxon, it has also been listed here as *'Vitrina'*. | Verdcourt places this 'problem' species in the Urocyclidae. |
| | | |
| | Most frequent at high altitudes but extending down to <2162m; widespread. Only poor, dead material was collected. | Verdcourt (1973) lists *iredalei* from Solai <Mt Kenya> leg. R. Kemp (2100-2700m) but notes that this probably refers to Solai above Nakuru. Not listed in Verdcourt (1983). Material from current study is close to *iredalei* (NMK material). Material examined by Verdcourt at MRAC from Mt Kenya also matches this species (Verdcourt, 1969) |
| E | | 2000-2300m (Germain) |
| | Verdcourt (pers, comm. 2001) identified Holm material from Rogati Forest, as possibly this taxon. | |
| E | Extends to >2606m but most frequent at low altitudes; widespread. | |
| | | An undescribed species tentatively assigned to *Halolimnohelix* (Verdcourt, 1983). |
| | | Pickford (1995) - Castle Rest House Station |
| | Extends to >2606m but most frequent at low altitudes; not recorded on Sirimon route. | Listed for Kenya highlands by Verdcourt (1983) |
| | | Bottom of forest zone (Germain). NMK material - Mt. Kenya 10,000 feet leg. Verdcourt. |
| E | | NMK material - paratypes from Teleki Tarn Mt. Kenya 14,000feet, leg. M.Coe. |
| E | | Teleki Valley, 12,800 feet leg. M. Coe. |
| E | | Verdcourt (1974) recorded this species from the Sirimon track in the *Hagenia- Podocarpus* forest under mossy logs from 9000' to 13,000 feet. |
| | | Undescribed species (Verdcourt 1983). |
| Near E | | Undescribed (Mount Kenya, Meru). |
| | | |
| | Low to High altitudes on Kamweti and Chogoria routes | NMK material - Sagana River 6400 feet. |
| | Mid altitudes on the Naro Moro and Sirimon routes | Matches material in NMK from Kenya bamboo forest, Uplands, leg & det. Verdcourt. |
| | | |
| | Low to high altitudes; widespread | |
| | | Germain noted this species was found between 2000-2300m (as *G. optata* ). Verdcourt & Polhill) records this species from Marimba |

# COMMENTS ON *MYXAS GLUTINOSA*

In a recent paper about *Myxas glutinosa* (Müller) (Carlsson, 2001[1]), some premature conclusions were drawn from the findings of 1998 and 1999. It was concluded that *Myxas* in autumn feeds on decaying leaves of water-lilies and that hibernation takes place at autumn overturn as temperature drops down to 4 ºC. As the investigation continued in 2000, the same pattern was not observed. Apart from an even more staggered breeding pattern, judged from individuals of varying sizes during all of the summer, individuals were becoming more regular in the end of August-beginning of September (heat sum ~ 1100 ºC). During the time water-lilies were decaying, few *Myxas* were seen on leaves. From November onwards the peaks, observed on leaves in October 1998 and 1999, appeared as conspicuous numbers of *Myxas* were seen on bare rocks where they probably grazed microalgae until the ice laid. The last individuals were seen in 0.5 ºC water under the first ice on December 20. All these new findings make *Myxas* an even more enigmatic species and contribute to its reputation as a vagrant species. Lymnaeids are known to show high plasticity in their lifecycles (Brown, 1979a[2]; b[3], 1985a[4]; b[5]) and *Myxas* seems to be extremely plastic.

Concerning the large-scale decline of *Myxas* (Whitfield *et al.*, 1998[6]), perhaps metapopulation ecology may explain why *M. glutinosa* holds sustainable populations despite its rareness and limited occurrence. The staggered breeding pattern, observed in the Alandian lakes may lead to asynchronous patch populations, making extinction less probable (Hanski, 1997). Some local populations may persist for a very long time, hence such "relict" populations may occur even if the species cannot any longer disperse in the landscape (Hanski, pers. comm.). Snails that are hermaphroditic or reproduce with parthenogenesis may be more successful in this respect than species with truly separate sexes. In aquatic plants it has shown that successful coloniser species with self-pollination or vegetative reproduction survive for longer times than species with cross-pollination (Krahulec & Leps, 1994[8]).

Metapopulation studies have mainly been carried out in terrestrial environments. Hanski (1999) refers to only one study dealing with water organisms. Maybe a metapopulation study approach on *Myxas* would be fruitful not only for *Myxas* studies, but also for the whole metapopulation theory.

[1] CARLSSON R. 2001 *J. Conch.* **37** (2): 105-117.

[2] BROWN K.M. 1979a *Hydrobiologia* **65**: 165-176.

[3] BROWN K.M. 1979b *Evolution* **33** (1): 417-432.

[4] BROWN K.M. 1985a *Evolution* **39** (2): 387-395.

[5] BROWN K.M. 1985b *Am. Malacol. Bull.* **3** (2):143-150.

[6] WHITFIELD M., CARLSSON R., BIGGS J., WALKER D., CORFIELD A., FOX G. & WILLIAMS P. 1998 *J. Conch. Special Publication No.2:* 209-222.

[7] HANSKI I. 1999 *Metapopulation ecology* Oxford University Press. 313 pp.

[8] KRAHULEC F. & LEPS J. 1994 *Fol. Geobot. & Phytotaxonomica* **29** (1): 3-14.

Ralf Carlsson

# REVIEWS

*Marine Shells of the Seychelles* by Alan G. Jarrett. 2000. Carole Green Publishing (2 Station Road, Swavesey, Cambridge, CP4 5QJ) 149 pp. ISBN 1-903479-00–2 Price £39.99 hardback. Conchological Society members ordering this book directly from the publishers will be given a 20% discount. Please refer to the Conchological Society when ordering.

Alan Jarrett spent ten years working as a teacher in the Seychelles; he took full advantage of the opportunity this provided to both collect and study local marine mollusca, thus this book is the culmination of extensive first-hand field work.

This identification guide gives detailed descriptions of some 649 species from the Seychelles, 535 gastropods and 114 bivalves. The species are arranged in standard taxonomic order, and alphabetically within each genus making the book very easy to use. Each species is clearly described and each description is complimented with a good quality colour photograph; these generally show both dorsal and ventral views of gastropods and both interior and exterior views of bivalves. The specimens illustrated all come from the Seychelles, where necessary using museum specimens to supplement those collected by the author. For completeness some 20 additional species reported from earlier literature are also mentioned in the text although without detailed descriptions or illustrations. It is particularly pleasing that a number of smaller species, often overlooked in popular works, are here given good coverage - species of *Engina, Rissoina, Truncatella, Fenella, Pyrene* and no less than 11 Triphorids. It is, however, surprising that nowhere in the descriptions of the Triphorids is it mentioned that these shells are sinistral; the illustrations clearly show this, but illustrations are often inadvertantly reversed; indeed elsewhere in this book both *Ovula ovum* and *Monilea vernicosa* are shown erroneously as apparently sinistral species.

Introductory sections of the book cover methods of collecting, cleaning shells, keeping molluscs alive in an aquarium, and the importance of recording data, and the book also contains a glossary, bibliography and index. One theme emphasised in the section on methods of collecting is that of responsible collecting with collectors urged to limit their 'take' to one or two specimens of any species, to avoid damaging living coral, to replace any disturbed stones or dead coral in their original positions etc. This theme recurs elsewhere in the book with the author commenting "When the female (Cowrie) is found protecting her egg capsule clusters she should not be collected, no matter how fine the specimen or how rare the species" and it is obvious that Alan Jarrett practices what he preaches for *Rapa rapa* is illustrated with beach collected specimens and the comment "Since this species lives imbedded in soft coral I have only collected washed specimens". We are also reminded that conservation regulations are in force in the Seychelles which must be observed by collectors.

One of the strengths of this book is the inclusion of much detailed observations of both the habits and habitats of many of the species covered. To give a few examples; the author observes of *Malea pomum* "I have collected mature specimens of this species ranging in length from 32-90 mm. The larger specimens were collected from deeper water." and that *Epitonium margarita* "Can be collected from sand beneath the solitary coral *Fungia* which is found resting on sand and appears to have some sort of association with this coral". *Maculotriton serriale* "is moderately common in shallow water, where it lives in coral debris on coarse sand... all colour forms seem to coexist in the same habitat". *Tonna dolium* is "Most easily collected at daybreak in depths of ten metres or more near Thallasia growing on a sandy sea bed. The animals are found buried with part of their shell projecting from the sand" while *Bursa cruentata* is found "Inhabiting holes in hard intertidal flats, particularly where the sea is inclined to be rough".

Descriptions of the cowrie shells are deliberately brief since "The group has been covered well in several major books"; instead the author provides detailed descriptions of the animals' appearance from his own observations. It is unfortunate that these descriptions of the living molluscs do not extend to other groups, we are for example tantalisingly told that *Haminoea simillima* 'Is uncommon but when found is usually one of a dozen or more that will be found nearby. They inhabit rock pools, moving through matted algal fronds. The animal is very beautiful but after it's removal leaves a thin white translucent shell", we are left wondering in what way the animal is beautiful.

There is some taxonomic confusion in a couple of places; *Pusia* is treated as both a full genus and as a subgenus of *Vexillum* while *Tellina* is treated as both full genus and as a subgenus of not only *Pharoanella* but also *Quadrans* and *Quidnapagus* (sic), whereas *Pharoanella, Quadrans* and *Quidnipagus* are all treated by Vaught as subgenera of *Tellina.* A small number of misidentifications have crept in, on p.48 *Cymatium hepaticum* appears to be the closely related *Cymatium closeli* Leu, 1987, on p.54 *Chicoreus maurus* is *Chicoreus saulii* (Sowerby, 1834) while on p.84/85 the species shown as *Marginella lilacina* is *Closia sarda* (Kiener, 1834). Judging from the Bibliography these few misidentifications probably stem from a lack of access to recent monographs, which may also explain the use of a number of old or invalid names, for example *Chicoreus palmarosae* (Lamarck) is generally in use today rather than *C. rosarius* (Perry) which is here treated as the valid name for the species.

There are one or two areas where this book could have benefited from some added editorial input, for example in the general bibliography where I would have expected to find the dates of publication for the works cited and where it would have been clearer had the authorship of publications been consistently given in the same format rather than intermixing Hinton Alan and Kensley Brian with Barry Wilson and Gary Rosenberg. In these examples it may be easy to distinguish the surname from the christian name, however, anyone who is not a native English speaker could have unnecessary problems, and without prior knowledge Kira Tetsuaki could be taken either way - Kira is the surname in this case. It is particularly regrettable that only one of the three principle references, detailing previous writings specifically on Seychelles mollusca, should have sufficient bibliographical information to be easily traced.

Despite any minor failings of taxonomy - which is prone to change anyway, and misidentifications - which can be easily corrected, this book is a fine example of the contribution which an amateur collector can make to conchology, through long term collecting, careful observation and recording and most importantly through publishing, whether in a full scale book like this or in smaller scale articles. There are many areas of the world where we could benefit greatly from similar studies, and anyone with similar opportunities should be encouraged to follow Alan Jarrett's lead and could do no better than to read this book as a good example of what can be achieved, 'Marine Shells of the Seychelles' will not only be useful as the first comprehensive modern book on the marine molluscs of the Seychelles but through it's detailed recordings of habitats will be beneficial to conchologists over a much wider area.

Kevin Brown

*An Atlas of Oxfordshire Terrestrial Mollusca* by S. J. Gregory and J. M. Campbell. 52 pp. Occasional Paper No. 20, published by Oxfordshire Museums in Co-operation with the Northmoor Trust. £4.00 + 54 p postage and packing (available from John Campbell, Oxon BRC, Oxfordshire County Museums Store, Witney Road, Standlake, Oxfordshire, OX8 7QG).

The value of mapping local distribution of snails by tetrads (2 x 2 km grid squares) has been shown by the published studies of the Isle of Wight (R. C. Preece) and Suffolk (I. J. Killeen). This Atlas is a worthy successor that records the distribution of land Mollusca in modern Oxfordshire (which comprises VC23, the 'old' Oxfordshire, plus part of VC22, north-western Berkshire). Like the earlier studies, it provides a more detailed picture of species' distribution than the national Atlas maps, allowing closer study of changes in status and the relationship between distribution patterns, geology and habitat types.

A coverage map at the beginning indicates that all but a handful of the tetrads were surveyed, and a total of more than 20 000 records was accumulated (unfortunately the map lacks a legend, so the actual number of species found in each tetrad is unclear). The thoroughness of geographical coverage is a substantial achievement, well justifying publication of this comprehensive check-list and set of distribution maps for Oxfordshire. Besides the two authors, Dr Arthur Spriggs is acknowledged as having contributed many of the records.

Coverage for most of the snails is evidently fairly comprehensive and complete enough to enable the authors to comment briefly on ecological and historical aspects of their distribution patterns. Indeed, the numerous records for such tiny snails as *Punctum pygmaeum* and *Carychium* shows the high quality of the survey work. Those involved in field recording will appreciate the sustained effort required to produce such good coverage, but we are unfortunately told little in the Atlas about the field methods used and recording strategy adopted. It is evident that slugs have been less comprehensively recorded, especially some recent segregates in the genus *Arion,* and the lack of dissections to check *Succinea putris* and *Oxyloma pfeifferi* is noted by the authors.

With 91 species known, Oxfordshire is one of the richer counties for landsnails and slugs. It is pleasing to see from the tetrad maps that such rarities as *Ena montana, Limax cinereoniger* and *Malacolimax tenellus* maintain strong populations in its woodlands. However, the maps show conspicuous declines of a few native species, most notably *Helicigona lapicida* and *Helicella itala,* whereas some introduced species have become widespread in the county, notably *Boettgerilla pallens.*

Overall, this modest publication provides a good record of the distribution of Oxfordshire land Mollusca. It seems a pity that the authors did not also include freshwater Mollusca, but this should not detract from the thorough coverage and careful recording evident in this Atlas.

Geraldine Holyoak

# FRANCIS DE BARTOLOMÉ (1917–2000) – OBITUARY

Francis de Bartolomé, President of the Society from 1979-1981, Honorary Member, Vice President, benefactor and former Honorary Legal Adviser and Trustee of the Society, passed away on 29 April 2000. He left a sister, Margaret, and a brother, Stephen, to whom the Society sends condolences.

John Francis Martine de Bartolomé was born on 24 January 1917 at his maternal grandparents' home in Sheffield the first child of Admiral Sir Charles, Controller of the Navy 1918-19, and Lady Gladys Martine de Bartolomé. From the age of five the family home was at Malvern. He was educated at Marlborough College. As a pre-war officer in the Territorial Army he served throughout World War II in the Hallamshire Battalion of the Yorkshire and Lancashire Regiment mostly as Adjutant at an army base at Beachley, Gloucestershire. This interrupted his training for a career but in 1946 he qualified as a solicitor with the Sheffield firm of Branson, Bramley and Company, with whom he spent his professional life, becoming a partner in 1956. On reaching the age of sixty, in 1977, Francis retired and moved from Sheffield to West Malvern where he and his younger sister Margaret had built a home, Highlow in de Walden Road, with spectacular views to the west. There he stayed happily, with 2-3 month holidays abroad each year, until 1995 when illness arising on a return flight from Barbados obliged him to be moved to a nursing home.

It is not absolutely certain how Francis first became interested in snails. This happened during his time at Marlborough, probably because a foot deformity (likely also to have confined him to Britain when in the Army) prevented him from participating in games, so he went for walks. Miss de Bartolomé recalls that on one of these outings he found an unusual snail and took it to a master who fortunately encouraged his interest and put him in touch with someone writing a book. From then on he was "hooked."

Francis joined the Conchological Society in 1949. By 1953 he was the Society's Honorary Legal Adviser, and he continued to be available to give legal advice until after his retirement from practice; during that time the Society had to undertake two law suits and also became a registered charity. Francis was also a Trustee from 1966 till late 1995. In 1976 he was made an Honorary Member for his work as Honorary Legal Adviser, and in 1980 he was elected President, serving the then customary two years. Thereafter, Francis remained a Vice President until his death. He was also a member of the Malacological Society of London from 1952 until his death.

Francis's main love was helicid snails, especially those of the Mediterranean region and in particular polymorphic rock-dwelling genera such as *Marmorana*. Where these were concerned he was interested in attempting, if possible, to simplify the voluminous nomenclature. To this end he travelled and collected from the Azores to Iran, and his conchological writings (see below) reflect visits to the Pitiuse and Balearic islands, Corsica, Sardinia, Spain, France, Sicily and Turkey. His large collection of predominantly non-marine but also marine material went to the Natural History Museum. The collection is particularly strong in Mediterranean species, especially such genera as *Marmorana, Iberus* and *Levantina* and it includes specimens (of shells and darts) of helicids produced during cross-breeding experiments carried out in containers at home. Francis wrote relatively little on molluscs, his publications being listed below, but did so in an inimitable anecdotal style, which holds the attention of the reader.

Despite his many travels, in some respects he seems to have been something of an "innocent abroad" so he could have problems. For example, his photographing of a bay in Franco's time, unwittingly coincided with the surfacing of a new Spanish submarine, so he spent a few days under arrest. Again in September 1972 Francis, his sister and nephew were robbed of possessions, money, passports and tickets by thieves breaking into their hire car at Çeyhan Yilankale in Turkey while they were looking at a castle ruin. As the possessions included the snails so far gathered (along with the plans for their West Malvern house) Francis's first act was to start re-collecting specimens while his nephew looked after the practicalities.

His generous bequests to the Society, for which we are most grateful, included his malacological library, being auctioned for the benefit of the Society. Although naturally strong in publications on European land molluscs it is considerably broader in scope and shows that Francis had general as well as particular molluscan interests.

Molluscs were not his only non-professional interest. He was very keen on motor cycles and as a rider he both participated in scrambles and undertook long journeys, such as to what was then Yugoslavia where he travelled with a friend on unmade roads. This hobby partly gave rise to his interest in railways because he would take his motorcycle on trains, until this became difficult, and he accumulated a considerable library especially on steam trains and timetables. Travel also brought him friends abroad, one of whom Anders Grøndahl produced a pen portrait (and photograph) of Francis for a Danish national newspaper.

A charming and polite character, he was capable of quite unexpected generosity (giving away collector's cabinets for instance) and was a born diplomat. For many years he was devoted to in his dog Budge. We miss him.

## ACKNOWLEDGEMENTS

I could not have written this account without the help of many others. Miss Margaret de Bartolomé provided essential biographical and family background; Adrian Norris, Marjorie Fogan and Elanor Fogan, Beryl Rands, Barry Colville, Tom Pain, Mark Davies membership secretary Malacological Society of London, helped to fill in more detail and Peter Mordan on Francis's collection.

David Long

## MOLLUSC RELATED PUBLICATIONS BY FRANCIS DE BARTOLOMÉ

BARTOLOMÉ, J.F.M. de 1970 Lusitanian Landsnails *Conchologists' Newsletter* No. **33** : 146–147.

BARTOLOMÉ, J.F.M. de 1976 The Case of the Snail (or Slug) in the Gingerbeer Bottle *Conchologists' Newsletter* No. **59**: 534–536.

BARTOLOMÉ, J.F.M. de 1981 Some thoughts about *Marmorana Journal of Conchology* **30**: 277–283 (Presidential address).

BARTOLOMÉ, J.F.M. de 1982 Comments on some Mediterranean rock-dwelling helicids *Journal of Conchology* **31**: 1–6 (Presidential address).

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# Journal of Conchology

Vol. 37, Part 3, July 2001

## Contents

PAGE

### PAPERS

ROSENBERG G. & PETIT R.E. On the unnecessary renaming of homonyms in Pyramidellidae. 245

PREECE R.C. Introduced land molluscs on the islands of the Tristan da Cunha - Gough group (South Atlantic). 253

RYAN S. & GRIFFITHS H.I. The decline and probable extinction of *Graecoanatolica macedonia* (Gastropoda: Orientallnidae) in Balkan Lake Dojran. 261

MANGANELLI G., CIANFANELLIA S., BREZZI M. & FAVILLI L. The distribution and taxonomy of *Vertigo moulinsiana* (Dupuy, 1849) in Italy (Gastropoda: Pulmonata: Vertiginidae). 267

TATTERSFIELD P., PAUL C.R.C. & ALLEN J.A. *Columella* in Sub-Saharan Africa: a range extension of over 4000 kilometres? 281

KOSUGE S. & OLIVERIO M. A new Coralliophiline species from the southwest Pacific (Neogastropoda: Muricidae: Coralliophilinae). 285

WARUI C.M., TATTERSFIELD P. & SEDDON M.B. Annotated checklist of the non-marine molluscs of Mount Kenya, Kenya. 291

### COMMUNICATIONS

CARLSSON R. Comments on *Myxas glutinosa*. 301

REVIEWS 303

OBITUARY 307

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